



**NUTRITION ACTION IN SCHOOLS:  
A REVIEW OF THE EVIDENCE  
RELATED TO THE  
NUTRITION-FRIENDLY  
SCHOOLS INITIATIVE**



**World Health  
Organization**



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# CONTENTS

<b>ACKNOWLEDGEMENTS</b>	<b>v</b>
<b>ABBREVIATIONS AND ACRONYMS</b>	<b>vi</b>
<b>EXECUTIVE SUMMARY</b>	<b>vii</b>
<b>BACKGROUND</b>	<b>1</b>
<b>METHODS</b>	<b>6</b>
Study design and evidence considered	6
Review of reviews	6
<i>Search strategies and inclusion criteria</i>	6
<i>Assessing the quality of review articles (Modified AMSTAR)</i>	6
<i>Data synthesis</i>	7
<b>RESULTS</b>	<b>9</b>
Summary characteristics of the evidence identified	9
<i>Search results</i>	9
<i>Review designs, study settings and population</i>	10
<i>Relevance of interventions and programmes to the NFSI essential criteria</i>	11
<i>Outcomes reviewed</i>	13
Narrative synthesis and summary of the synthesized evidence	13
<i>NFSI Component 1: Having a nutrition-friendly schools policy</i>	13
<i>NFSI Component 2: Enhancing awareness and capacity building of the school community</i>	28
<i>NFSI Component 3: Developing a nutrition and health promoting curriculum</i>	37
<i>NFSI Component 4: Creating a supportive environment</i>	52
<i>NFSI Component 5: Providing supportive school nutrition and health services</i>	71
<b>DISCUSSION AND CONCLUSIONS</b>	<b>74</b>
Summary of findings	74
Strengths and limitations	75
Future research	76
Conclusion	78
<b>REFERENCES</b>	<b>80</b>
<b>ANNEX 1 SUMMARY OF EXPERIENCE IN PILOTING, IMPLEMENTING AND EVALUATING THE NFSI IN COUNTRIES</b>	<b>93</b>
<b>ANNEX 2 DETAILS OF REVIEWS INCLUDED</b>	<b>95</b>





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# ABBREVIATIONS AND ACRONYMS

<b>AMSTAR</b>	Assessment of Multiple Systematic Reviews	<b>NFSI</b>	Nutrition-Friendly Schools Initiative
<b>BMI</b>	body mass index	<b>NUGAG</b>	WHO Nutrition Guidance Expert Advisory Group
<b>CBA</b>	controlled before and after	<b>OR</b>	odds ratio
<b>CI</b>	confidence interval	<b>PA</b>	physical activity
<b>DBP</b>	diastolic blood pressure	<b>PE</b>	physical education
<b>eLENA</b>	WHO e-Library of Evidence for Nutrition Actions	<b>PR</b>	prevalence ratio
<b>F&amp;V</b>	fruit and vegetables	<b>RCT</b>	randomized controlled trial
<b>FAO</b>	Food and Agriculture Organization of the United Nations	<b>RR</b>	relative risk
<b>FFE</b>	food for education	<b>SBP</b>	systolic blood pressure
<b>GNPR2</b>	Second WHO Global Nutrition Policy Review 2016-2017	<b>SDG</b>	Sustainable Development Goal
<b>HAZ</b>	height-for-age z-score	<b>SDS</b>	standard deviation score
<b>HDL-C</b>	high-density lipoprotein-cholesterol	<b>SMD</b>	standard mean difference
<b>HIC</b>	high-income countries	<b>SSB</b>	sugar-sweetened beverage
<b>HPS</b>	WHO Health Promoting Schools	<b>UMIC</b>	upper-middle-income countries
<b>ICT</b>	information and communication technology	<b>UNESCO</b>	United Nations Educational, Scientific and Cultural Organization
<b>IDD</b>	iodine deficiency disorders	<b>UNICEF</b>	United Nations Children's Fund
<b>LDL-C</b>	low-density lipoprotein-cholesterol	<b>UNSCN</b>	United Nations System Standing Committee on Nutrition
<b>LIC</b>	low-income countries	<b>USDA</b>	United States Department of Agriculture
<b>LMIC</b>	lower-middle-income countries	<b>WASH</b>	water, sanitation and hygiene
<b>MD</b>	mean difference	<b>WAZ</b>	weight-for-age z-score
<b>MMN</b>	multiple micronutrient	<b>WFP</b>	World Food Programme
<b>MNP</b>	micronutrient powders	<b>WHO</b>	World Health Organization
<b>MUAC</b>	mid-upper arm circumference	<b>WMD</b>	weighted mean difference
<b>NCD</b>	noncommunicable disease		



# EXECUTIVE SUMMARY

**G**ood nutrition during childhood and adolescence is key to ensuring optimal growth, health and well-being. Healthy dietary practices in early life have an immediate impact on healthy growth and help prevent noncommunicable diseases (NCDs) later in life and across generations. Good nutrition in childhood is also good for school performance and educational outcomes, impacting on nations' economic and social development.

Since children spend so much time in school, the school environment is an important setting for children to acquire habits, skills and knowledge related to healthy diets and physical activity. In 2016-17, the vast majority of countries (89%) reported implementation of school health and nutrition programmes although inclusion of a comprehensive set of interventions was rare and implementation of such programmes appears to have weakened since the start of the decade.

## The Nutrition-Friendly Schools Initiative

In 2006, building on existing programmes and initiatives including the Health Promoting School approach and the FRESH (Focusing Resources on Effective School Health) Initiative, WHO and partners launched the Nutrition-Friendly Schools Initiative (NFSI) to provide a framework for ensuring integrated school-based programmes which address the burden of nutrition-related ill health, whether that be undernutrition and/or overweight/obesity. The NFSI has since been used around the world, including as a self-appraisal tool for schools in 18 countries, in national NFSI programmes and as part of academic research and evaluation projects.

The NFSI Framework outlines 26 essential criteria within five broad components:

1. school nutrition policies
2. awareness and capacity building of the school community
3. nutrition and health promoting curricula
4. supportive school environment for good nutrition
5. supportive school nutrition and health services.

## Review methodology and evidence identified

This review aims to identify and summarize the synthesized evidence from reviews related to the five components and the 26 essential criteria of the NFSI, and to highlight areas where more research is needed.

In total, 117 reviews were included: 43 meta-analyses, 63 systematic reviews (including eight Cochrane reviews) and 11 other reviews. The studies included in the reviews were published between 2006 and 2019, and most reviews required studies to follow an experimental design. The vast majority of studies included were based in high-income countries, and only nine reviews exclusively or largely included studies exclusively from low- and middle-income countries while another four reviews focused on disadvantaged population groups in high-income countries. Most reviews considered studies at the primary and/or secondary school level, while fewer included studies in preschool establishments. A 10-item modified version of the Assessment of Multiple Systematic Reviews (AMSTAR) method was used to assess the quality of the reviews collected.



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The included reviews provided an analysis of a wide range of school-based interventions. There was a high level of heterogeneity in relation to the school-level exposures, the impact on children and the outcome measures. Due to the differences in study aims, methods and measures, meta-analysis was not appropriate and the findings are summarized in a narrative way.

## Summary of findings

Evidence from the included reviews is summarized for each of the relevant NFSI components, with many reviews relevant to multiple components and criteria.

### NFSI Component 1: Having a written nutrition-friendly schools policy

#### Essential criteria

- 1.1 Development of a written nutrition-friendly schools policy that addresses all five points described in this framework, and includes elements described in 1.2 - 1.5
- 1.2 Rationale
- 1.3 Objectives
- 1.4 Action plan
- 1.5 Monitoring and evaluation plan

Twenty-three meta-analyses and 28 reviews were identified that examined various aspects of comprehensive school nutrition policies and programmes relevant to essential criterion 1.1. Findings suggest that comprehensive school nutrition policies using multiple components and approaches (e.g. diet, physical activity, educational interventions, environmental changes) are associated with positive weight-related, dietary and other outcomes among school children. Improvements in BMI standard mean difference (SMD) ranged from  $<-0.1\text{kg/m}^2$  to  $-1.8\text{kg/m}^2$  through school-based programmes. The majority

of the reviews considering multicomponent programmes combining diet and physical activity interventions found this combination effective in addressing weight-related outcomes. A smaller number of reviews examined combinations of approaches, e.g. nutrition improvement through curriculum, environment and parental involvement, and also found positive effects. The four reviews which focused specifically on low- and middle-income countries or vulnerable populations in high-income countries reported positive effects on weight-, diet- or health behaviour-related outcomes from multicomponent

***“ The majority of the reviews considering multicomponent programmes combining diet and physical activity interventions found this combination effective in addressing weight-related outcomes ”***



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school nutrition programmes. Only one scoping review which examined facilitators and barriers to implementing school nutrition policies was identified that could shed some light on essential criteria 1.2 to 1.5.

#### **NFSI Component 2: Enhancing awareness and capacity building of the school community**

##### *Essential criteria*

- 2.1 Dissemination of the nutrition-friendly schools policy
- 2.2 Activities for families and community, community involvement and outreach in the area of nutrition and health related issues
- 2.3 School staff training in nutrition and health related issues

Fourteen meta-analyses and 18 reviews were identified relevant to essential criterion 2.2, examining family and community involvement in school nutrition programmes. A large number of reviews found positive effects from enhancing awareness and capacity building of the wider school community. The effect of engaging families and communities through community involvement and outreach in the area of nutrition and health-related issues was the most frequently studied intervention. Parental involvement was identified as a moderating factor leading to better results (e.g. on body mass index (BMI) or other weight-related, biochemical or dietary outcomes),

***Parental involvement was identified as a moderating factor leading to better results (e.g. on body mass index (BMI) or other weight-related, biochemical or dietary outcomes) with a greater impact for a higher level of parental involvement***

with a greater impact for a higher level of parental involvement. Direct involvement methods (e.g. face-to-face), where parents are expected to take an active role, were more effective than indirect methods (e.g. newsletters), where parents may remain passive recipients of information. Less evidence was identified for the effect of staff training in delivering nutrition and healthy diet interventions relevant to essential criterion 2.3, but from the five reviews identified beneficial effects were noted from training teachers and involving experts in school-based nutrition activities. No reviews were identified relevant to essential criterion 2.1.

#### **NFSI Component 3: Developing a nutrition and health-promoting school curriculum**

##### *Essential criteria*

- 3.1 Culturally-appropriate and effective nutrition education
- 3.2 Age, sex and culturally-appropriate physical education curriculum
- 3.3 Healthy living and life-skills education curriculum
- 3.4 Regular monitoring of school curriculum relevant to NFSI, and evaluation of impact of how well the education meets the objectives



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Ten meta-analyses and 28 reviews were identified relevant to essential criterion 3.1 that examined various aspects of nutrition education in schools. Eight of the 10 meta-analyses found significant improvements in weight-related or dietary outcomes. Effective nutrition education programmes were behaviourally-focused, context and age-specific, of longer duration and intensity, facilitated by trained staff, integrated into the curricula and/or implemented in combination with other approaches (e.g. changes to the environment). Hands-on learning strategies and practical skills were considered promising, as were those that built children's self-efficacy in making healthy changes in their diet and physical activity levels. Thirteen meta-analyses and four systematic reviews were identified relevant to essential criterion 3.2 comparing physical activity education alone or in combination with nutrition activities. The majority of these found that physical activity education was more effective when combined with nutrition interventions. Eight reviews were identified relevant to essential criterion 3.3 examining life-skills education in the context of nutrition. Effective intervention components were suggested to be experiential learning, such as cooking or gardening skills. Self-efficacy and children's perceived competence in making healthy changes to their diet and physical activity levels were found to be associated with better outcomes. No reviews were identified relevant to essential criterion 3.4.

***Effective nutrition education programmes were behaviourally-focused, context and age-specific, of longer duration and intensity, facilitated by trained staff, integrated into the curricula and/or implemented in combination with other approaches***

#### NFSI Component 4: Creating a supportive school environment

##### *Essential criteria*

- 4.1 School meals, food vendors and snack bars (if present) promote healthy eating
- 4.2 Positive messaging towards nutrition and active living
- 4.3 Absence of marketing of foods and beverages at school
- 4.4 Access to an adequate eating place if the school provides food and/or beverages to the children
- 4.5 Adequate school cooking facilities
- 4.6 Access to safe drinking water
- 4.7 Promotion of safe hygiene and sanitary behaviour
- 4.8 Availability of clean and separate toilets, for boys and girls
- 4.9 Opportunity for all age groups to access space and school sporting facilities for physical activity within and outside of the curriculum
- 4.10 Affirmative action against bullying, stigmatization and discrimination
- 4.11 School staff as role-models in encouraging healthy eating and healthy lifestyle

Nine meta-analyses and 24 reviews were identified that considered either the availability of foods and beverages or the provision of foods, beverages or snacks, relevant to essential criterion 4.1. Many of these reviewed current policies and standards implemented in countries. There was a considerable body of evidence to support the creation of healthy environments for nutrition, particularly through increasing availability of healthy foods and beverages and simultaneously reducing availability of unhealthy foods and beverages. Positive effects were reported on dietary and food availability outcomes from school lunch standards, restrictive policies on unhealthy foods and beverages and school food procurement policies. Provision of school food had positive effect in low-income or disadvantaged settings, including school feeding programmes, provision of fortified

foods and school breakfast programmes. Provision of fruit and vegetables in schools increased children's consumption.

***There was a considerable body of evidence to support the creation of healthy environments for nutrition, particularly through increasing availability of healthy foods and beverages and simultaneously reducing availability of unhealthy foods and beverages***

Less evidence was identified relevant to other essential criteria in this NFSI component. Relevant to essential criterion 4.2, two meta-analyses and seven systematic reviews considered messaging, incentivising desired behaviour or use of labelling to encourage healthy eating in the school setting. These reported positive effects on diet-related outcomes but mixed results for weight-related outcomes. Relevant to essential criterion 4.3, one review found that children are commonly exposed to marketing of unhealthy foods and beverages in and around schools and that restrictive policies — where they existed — were often breached. Relevant to essential criteria 4.4 and 4.5, one systematic review identified overcrowding in the cafeteria or lack of appropriate kitchen facilities and equipment as barriers to healthy school food environments. Relevant to essential criterion 4.6, three systematic reviews analysed the effect of access to safe drinking water on consumption of water or sugar-sweetened beverages (SSBs) and weight-related outcomes. Relevant to essential criterion 4.7, one meta-analysis and one systematic review found that adequate hand washing and sanitation in schools reduced risk of diarrhoea, amongst other outcomes. Relevant to

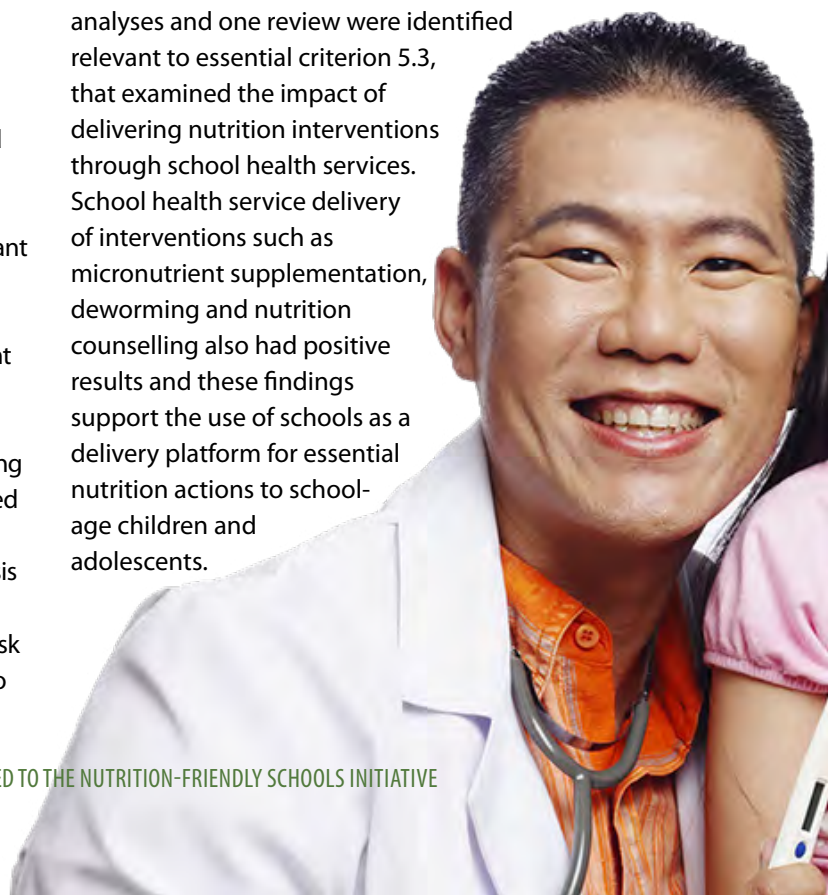
essential criterion 4.11, one meta-analysis and two systematic reviews found that modelling healthy dietary behaviours by parents, peers or teachers had positive effects. No reviews were identified relevant to essential criteria 4.8, 4.9 and 4.10.

#### **NFSI Component 5: Providing supportive school nutrition and health services**

##### *Essential criteria*

- 5.1 Regular monitoring of children's growth development
- 5.2 Effective feedback system for parents and children on findings of the regular monitoring
- 5.3 Supportive school health service, including a referral system

Some evidence was identified regarding supportive school health services for nutrition. One meta-analysis and one review examined regular monitoring and feedback for children's growth, relevant to essential criteria 5.1 and 5.2. School-based weight monitoring and screening programmes demonstrated positive effects in both children and their families. Three meta-analyses and one review were identified relevant to essential criterion 5.3, that examined the impact of delivering nutrition interventions through school health services. School health service delivery of interventions such as micronutrient supplementation, deworming and nutrition counselling also had positive results and these findings support the use of schools as a delivery platform for essential nutrition actions to school-age children and adolescents.





## Strengths and limitations

The bulk of evidence considered in this review was from high-income countries focusing on obesity prevention and this imbalance constitutes a major bias. Other limitations of the review include the high level of heterogeneity amongst studies in the reviews, the likelihood of small study bias and the difficulty of drawing conclusions about the effects of programme components individually when they are implemented as part of a multicomponent package. There were also great differences in categorization (e.g. of “diet” and “physical activity” interventions or content and intensity of “nutrition education” interventions) between reviews. In addition, many of the studies included relied on cross-sectional data which are unable to measure long-term effects.

Nonetheless, this review has comprehensively and systematically assessed and summarized the evidence underpinning the NFSI criteria, on the basis of 117 reviews synthesizing findings from primary studies.

## Conclusions

This review of reviews provides an extensive summary of the evidence for the effectiveness of many components of the NFSI framework. The findings may be used — in conjunction with existing UN and WHO guidance and tools — to inform the work of governments, policy-makers and researchers concerned with school-based health and nutrition promotion programmes and initiatives.

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A strong evidence base to support many specific criteria of the NFSI was identified. This highlighted, for example, the importance of having comprehensive nutrition-related school policies, involving parents in school-based nutrition interventions, implementing effective nutrition and physical activity education, creating healthy school food environments and integrating nutrition into school health services through, for example, school-based monitoring of children’s growth.

Synthesized evidence on the nutrition impact of other criteria, however, such as the dissemination of school nutrition policies, monitoring and evaluation of school nutrition-related curricula, separate toilets for boys and girls, access to physical activity spaces and the need to prevent bullying, do not yet exist. The review also points to the need for more research on school nutrition policies and programmes in low- and lower-middle income countries and on educational outcomes, as well as health and nutrition outcomes.

Member States are encouraged to draw on this evidence base and to use the NFSI framework to build school nutrition-related policies and programmes appropriate to their particular country schooling system and nutrition situation. In doing so, they can fully realize the potential of schools as a key setting for improving nutrition throughout childhood and adolescence, while laying good foundations for health and well-being later in life.

***/// School health service delivery of interventions such as micronutrient supplementation, deworming and nutrition counselling also had positive results and these findings support the use of schools ///***



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# BACKGROUND

**N**utrition during childhood and adolescence is key to ensuring optimal growth, health and well-being during childhood and beyond (1, 2). Healthy dietary practices and the foundation for good nutrition are initiated in early life stages, with an immediate impact on healthy growth during this period characterised by rapid growth spurts. They also have long-term health impact, such as the prevention of noncommunicable diseases (NCDs) later in life, as well as inter-generational impact through ensuring optimal nutrition status of mothers, particularly those who are adolescent girls (1, 3). Moreover, a child who has good health and nutrition performs better in school (4, 5), and a good education provides a child with a foundation for the future, which in turn impacts on nations' economic and social development (6, 7). While the focus of the critical period to ensure good nutrition typically has been on the first 1000 days — from conception to a child's second birthday — there is now growing recognition of the importance of the subsequent 7 000 days, which includes critical childhood and adolescent periods up to the age of 21, to reach their full development potential (8, 9).

From a human rights perspective, school-based nutrition policies and programmes may be an effective mechanism for contributing to the realization of children's rights to the highest attainable standard of health, to adequate food and to education. Schools play an important role in promoting nutrition by providing access to children from a range of socioeconomic backgrounds. Young people spend a considerable amount of time in school, so school-based programmes will reach many children in a relatively short period of time and, therefore, the school environment is an ideal setting to acquire habits, skills, and knowledge related to healthy diets and physical activity (10). Additionally, school programmes provide an infrastructure (such as a network of teachers and staff, along with facilities) which may contribute to the sustainability of an intervention over time (10, 11).

The second Global nutrition policy review 2016-2017: country progress in creating enabling policy environments for promoting healthy diets and nutrition (GNPR2) (12) undertaken in 2016-2017 reported that 89% of 160 countries reporting on school health and nutrition programmes implemented related actions. The most frequently reported component of school health and nutrition programmes was nutrition education being included in the school curriculum (61%), followed by training of school staff on health and

nutrition (56%). More than half of the countries had standards or rules for foods and beverages in schools (54%), provided school meals (54%) or made safe drinking water available free of charge (53%). Provision of school meals was most common in the WHO regions of Africa and South-East Asia; however, not all countries providing meals had standards or guidance for school meals. Other actions to support healthy diets or improve the school food and beverage environment were less common. Only 18% of countries had a ban on vending machines, 24% had standards for regulating marketing of foods and beverages in schools and 30% had school fruit and vegetable schemes. Just over half of the countries provided any fruit and vegetables at school through school meals or fruit and vegetable schemes. But there were misconceptions about healthy options, with several countries providing 100% fruit juices, which often contain as much (or even more) free sugars as some other SSBs including soft drinks. The most common school health and nutrition services were growth monitoring (43%), deworming (36%) and micronutrient supplementation (19%).

Furthermore, in contrast to other nutrition-related programme areas surveyed in the GNPR2, there had been a notable weakening in most specific school health and nutrition programme components since the first such review in 2009-2010 (13). All

the regions saw large overall decreases in most programme components, although there were some exceptions; for example, increased inclusion of deworming and safe drinking water in the WHO African Region and of growth monitoring and deworming in the WHO Eastern Mediterranean Region. This may well reflect an increased focus by national nutrition authorities on the 1000 days window, which is a critical period for healthy growth and development, as well as prevention of stunting. Nonetheless, it is during school years that children can and should learn the importance of a healthy diet and acquire healthy eating habits, to help prevent all forms of malnutrition. There are, however, still countries where school food programmes are not linked to nutrition and health considerations. In a recent survey of school meal programmes in 33 low- and middle-income countries by the Food and Agriculture Organization of the United Nations (FAO) (14), some country programmes did not include as main objectives improving nutrition, learning healthy dietary habits or improving the quality of school meals.

The importance of schools in promoting population health is widely

acknowledged. WHO launched the Global School Health Initiative in 1995 with the intention of strengthening health promotion and educational activities aimed at improving the health of students and the surrounding school community. Since then, numerous countries have implemented the WHO Health Promoting Schools approach based on the Global School Health Initiative. A health promoting school constantly seeks to strengthen its capacity to promote healthy living, learning and working conditions. It aims to provide a multifaceted response to the health needs of students. Its key features are to engage health education and community leaders, provide a safe healthy environment, provide skills-based health education, provide access to health services, improve health promoting policy and practice and improve the health of the community. Healthy nutrition has been considered an “essential element of a health promoting school” (15).

WHO, in partnership with FAO, the United Nations Children Fund (UNICEF), the United Nations Educational, Scientific and Cultural Organization



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(UNESCO), the World Food Programme (WFP), the World Bank Group, Education Development Center, Save the Children (SC), Partnership for Child Development, University of Montreal, Durham University and the United Nations System Standing Committee on Nutrition (UNSCN), as well as government agencies from Brazil, Finland and Ireland, developed the Nutrition-Friendly Schools Initiative (NFSI). The initiative was launched in 2006 to provide a framework for ensuring integrated school-based programmes which address the double burden of nutrition-related ill health and to become the nutrition module of the Health Promoting Schools. The NFSI builds on and connects the work from other programmes such as the Focusing Resources on Effective School Health (FRESH) Initiative (16), UNICEF and WFP's Essential Package (17), UNICEF's Child-Friendly Schools (18), WHO's Health Promoting Schools (19) and FAO's curriculum planning guide for nutrition education in primary schools (20), to mention a few.

The rationale behind the development of the NFSI was to provide common policy options that enable schools to implement programmes and improve the health and nutrition status of young people. The NFSI targets the school setting, including preschool, primary and secondary schools. Building on the FRESH framework and the Health Promoting School approach, the NFSI Framework outlines 26 essential criteria within five broad components:

1. school nutrition policies
2. awareness and capacity building of the school community
3. nutrition and health promoting curricula
4. supportive school environment for good nutrition
5. supportive school nutrition and health services (Box 1).

The components and essential criteria were developed by WHO and partners based on a number of sources. These include the outcomes

of the WHO Expert Meeting on Child Obesity, held in Kobe, Japan in 2005 (21), a conceptual meeting held in Montreux, Switzerland in 2006 (22), the content of ongoing school-based programmes to address all forms of malnutrition, a 2005 Cochrane systematic review (23), a 2006 review of studies by the National Institute for Health and Clinical Excellence in the United Kingdom (24) and a 2006 qualitative review by Flynn et al. (25).

In the years following its development, the NFSI has been used around the world. As a self-appraisal tool for schools, NFSI has been piloted in 18 countries, mainly in the European region and a handful of other countries including Brazil, India, Benin and Burkina Faso (26). Some countries still have national NFSI policies and programmes, such as Turkey where the General Directorate of Public Health reports that more than 16 000 schools in the country participate in the Turkish Nutrition-Friendly Schools Program (27). The NFSI framework was recently used by University of Oxford researchers to evaluate school nutrition policies before and after multisectoral health promotion programmes and initiatives. A brief summary of experience in piloting, implementing and evaluating the NFSI is provided in Annex I.

To date, there has not been a published review of the scientific evidence behind all five components of the NFSI in one single document, including the relationship between the recommendations and the associated nutrition-related outcomes among school children. The purpose of this review is to identify and summarize the synthesized evidence related to the NFSI components and essential criteria, and to highlight areas where more research is needed.

Since the development of the NFSI Framework in 2006, WHO has taken important steps to further advance the agenda of promoting healthy diets and good nutrition in the school setting. In 2016, the implementation plan for the recommendations of the Commission on Ending Childhood Obesity (28) identified settings such as schools and child care

## Box 1. The Nutrition-Friendly Schools Initiative framework

### 1. Having a written nutrition-friendly schools policy

#### *Essential criteria*

- 1.1 Development of a written nutrition-friendly schools policy that addresses all five points described in this framework, and includes elements described in 1.2 - 1.5.
- 1.2 **Rationale:** e.g. promotion of healthy diet and eating practices, increased physical activity; prevention of undernutrition, micronutrient deficiencies, overweight and/or obesity and other nutrition-related chronic diseases; also, contributory conditions such as unhygienic school environments, untrained school staff, lack of information in the community.
- 1.3 **Objectives:** with timelines and clear milestones.
- 1.4 **Action plan:** Outline of the whole-school approach contributing to healthy living and lifestyles to include description of processes, organizational structure, roles and responsibilities, principles of rights/ equity/ non-discrimination and strong commitment by all concerned stakeholders, including families and communities.
- 1.5 **Monitoring and evaluation plan** for the nutrition-friendly schools policy.

### 2. Enhancing awareness and capacity building of the school community

#### *Essential criteria*

- 2.1 Dissemination of the nutrition-friendly schools policy.
- 2.2 Activities for families and community, community involvement and outreach in the area of nutrition and health-related issues.
- 2.3 School staff training in nutrition and health-related issues.

### 3. Developing a nutrition and health-promoting school curriculum

#### *Essential criteria*

- 3.1 Culturally-appropriate and effective nutrition education.
- 3.2 Age, sex and culturally-appropriate physical education curriculum.
- 3.3 Healthy living and life-skills education curriculum.
- 3.4 Regular monitoring of school curriculum relevant to NFSI, and evaluation of impact of how well the education meets the objectives.

### 4. Creating a supportive school environment

#### *Essential criteria*

- 4.1 School meals, food vendors and snack bars (if present) promote healthy eating.
- 4.2 Positive messaging towards nutrition and active living.
- 4.3 Absence of marketing of foods and beverages at school.
- 4.4 Access to an adequate eating place if the school provides food and/or beverages to the children.
- 4.5 Adequate school cooking facilities.
- 4.6 Access to safe drinking water.
- 4.7 Promotion of safe hygiene and sanitary behaviour.
- 4.8 Availability of clean and separate toilets, for boys and girls.
- 4.9 Opportunity for all age groups to access space and school sporting facilities for physical activity within and outside of the curriculum.
- 4.10 Affirmative action against bullying, stigmatization and discrimination.
- 4.11 School staff as role-models in encouraging healthy eating and healthy lifestyle.

### 5. Providing supportive school nutrition and health services

#### *Essential criteria*

- 5.1 Regular monitoring of children's growth development.
- 5.2 Effective feedback system for parents and children on findings of the regular monitoring.
- 5.3 Supportive school health service, including a referral system.

facilities as key settings for delivering nutrition and health education, increasing opportunities for physical activity and promoting a healthy school environment. In 2017, WHO and partners launched the *Global Accelerated Action for the Health of Adolescents (AA-HA!): Guidance to support country implementation* document, which provides guidance for implementing comprehensive adolescent health programmes and services specific to the health needs of adolescents, including nutrition interventions (10, 11). Many actions suggested by the AA-HA! Guidance could be offered and implemented in the school environment. In 2018, WHO and

UNESCO launched the *Making Every School a Health Promoting School* initiative through the development and promotion of *Global Standards for Health Promoting Schools* (29). The initiative will serve over 2.3 billion school-age children, and will contribute to WHO's *Thirteenth General Programme of Work 2019 - 2023*<sup>1</sup> target of achieving 1 billion more people enjoying better health and well-being by 2023 (30). Furthermore, WHO is currently developing guidelines on school food and nutrition policies, in the context of protecting and promoting healthy diets for children, as well as on school health services including nutrition.

<sup>1</sup> WHA 71.1



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# METHODS

## STUDY DESIGN AND EVIDENCE CONSIDERED

**T**his review draws upon research findings from reviews that pertain to the essential criteria of the NFSI. These criteria cover a broad range of research and the relevant scientific literature is very heterogeneous in terms of research questions, study design, interventions and outcome measures. Therefore, meta-analysis was not appropriate for this review and findings from the relevant literature are summarized using a narrative approach.

## REVIEW OF SYSTEMATIC REVIEWS

### *Search strategies and inclusion criteria*

To be included in this exercise, reviews were required to present results of interventions or exposures to school components that relate to those recommended within the NFSI essential criteria (Box 1). Since school-based programmes seldom focus on single interventions, reviews were included if they evaluated the effect on nutrition-related outcomes<sup>1</sup> of school-based interventions related to the NFSI essential criteria as primary intervention(s) or in combination with other interventions, in a way that made it possible to link findings to specific essential criteria. For reviews considering multiple settings to be included, either a majority of the primary studies should have taken place in the school setting or the review presented separate subgroup analyses for the school setting. There were no geographical restrictions.

Reviews were identified through a keyword search for synthesized literature conducted in school settings assessing the impact of interventions related to the 26 NFSI essential criteria (e.g. school policies, community and parental involvement, training of staff, curricula and education, school foods and beverages and other school nutrition-related environment, nutrition services delivered in schools) and measuring nutrition-related outcomes (e.g. weight- or diet-related, food literacy).

<sup>1</sup> Reviews analysing the effect of interventions on outcomes relating to nutrition status, diet and nutrition-related disease were included, whereas reviews analysing the effect of interventions solely on outcomes not directly relating to nutrition status – such as school performance or physical activity levels – were excluded.

The PubMed, Campbell, 13E UKAID, Cochrane library and PDQ-Evidence databases were searched on multiple occasions between 2012 and 2019 for relevant reviews published in English language between January 2006 and August 2019. Additional reviews were added as result of a peer review in 2019 by school health and nutrition programme focal points in the United Nations agencies and experts who have supported the implementation of the NFSI.

One researcher reviewed titles and abstracts from the search results. Cases of doubt were resolved via consensus with another reviewer. Two research team members reviewed most of the remaining full text articles. An extraction sheet was used to identify each study's aims, methods, inclusion criteria, study population and setting, overall results (e.g. description of studies included, study effect of interventions) and relevance to the NFSI essential criteria.

### *Assessing the quality of review articles (Modified AMSTAR)*

A 10-item modified version of the Assessment of Multiple Systematic Reviews (AMSTAR) method was used to assess the quality of the reviews and systematic reviews collected. AMSTAR was developed using factor analysis to reduce a 37-item assessment tool, the Overview Quality Assessment Questionnaire, to a shorter one (31). AMSTAR was tested for validity (32-34) and reliability (34) and was found to have good agreement, reliability, construct validity and feasibility. In this review of reviews, a modified version of this tool was used, which retained



most of the items, including research design, data extraction methods, literature search methods, publication status of included reviews, description of inclusion/exclusion process and results, assessment study quality, testing for homogeneity/heterogeneity and disclosure of potential conflict of interest. Weighting was applied to 10 items, each with between one and six sub items, with each sub item equally summed up to give one mark per item. The total of the 10 items (marks) was then divided into terciles, designating low-, medium-, and high-quality grades, respectively.

### ***Data synthesis***

As noted previously, due to differences in study aims, methods, and measures, meta-analysis was not appropriate. Therefore, findings are summarized in a narrative way, grouped according to the relevant NFSI criteria. Many studies were relevant to more than one component of the NFSI.



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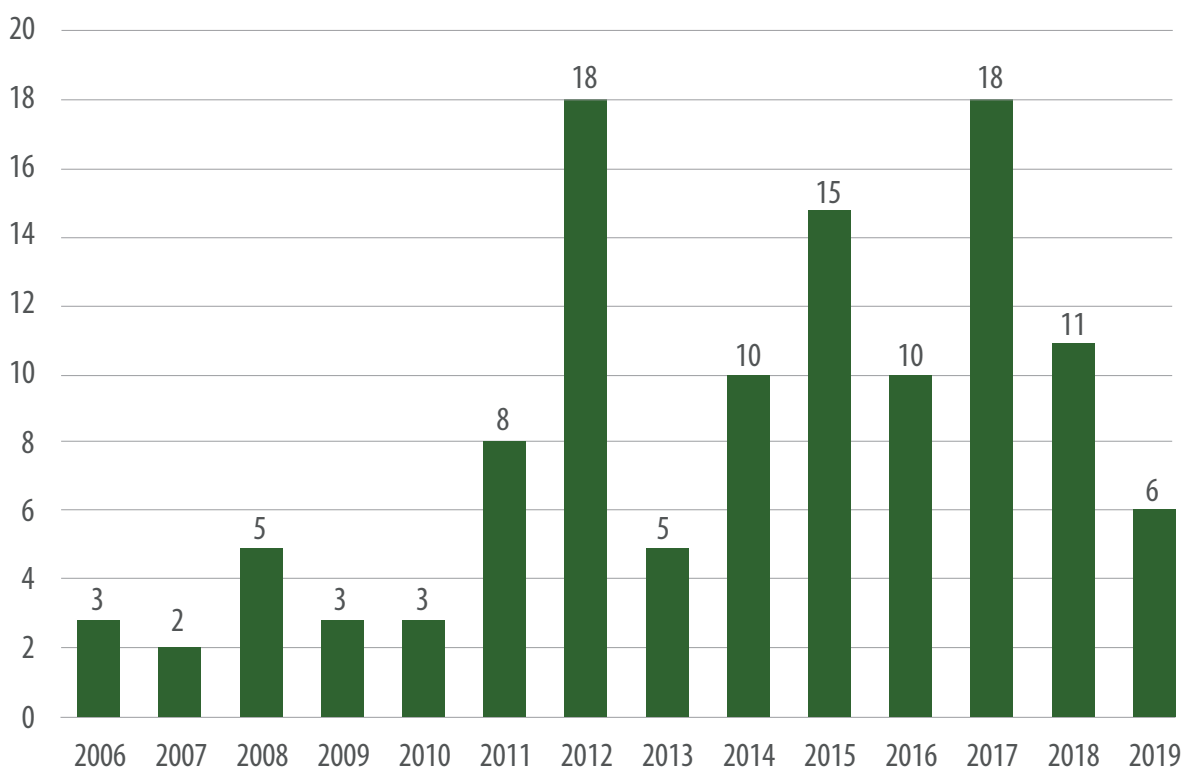
# RESULTS

## SUMMARY CHARACTERISTICS OF THE EVIDENCE IDENTIFIED

### Search results

The search as described was executed on various occasions over the period during which this review has been conducted. This resulted in initial search results of more than 2 000 results. After title and abstract screening, 228 articles were evaluated based on the full text, of which 117 reviews met the inclusion criteria and 111 reviews were excluded.<sup>1</sup> The included reviews were published between 2006 and 2019, with 60% of the reviews published since 2014 (Fig. 1). Details of the reviews are included in Annex II.

Figure 1. Number of reviews included by year of publication



<sup>1</sup> The 111 reviews were excluded because they were not conducted in a school setting or did not provide subanalysis of school-based studies (13 reviews), did not include interventions relevant to the NFSI framework (6), lumped interventions together in the analyses so they could not be allocated to specific NFSI essential criteria (39), did not evaluate nutrition interventions or measure impact on nutrition outcomes (19), did not evaluate the effectiveness of interventions (22) or focused on physical activity interventions only (12).

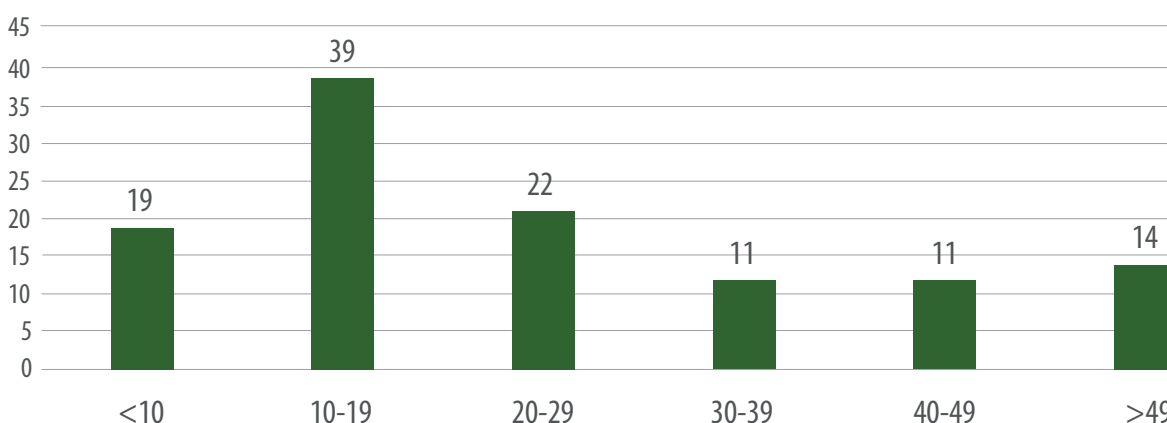
### Review designs, study settings and population

Of the 117 reviews included, there were 43 meta-analyses, 63 systematic reviews (including eight Cochrane reviews) and 11 other reviews (e.g. literature reviews, scoping reviews). Most of these reviews required studies to follow an experimental design, including randomized controlled trials (RCTs) or other studies with pre- and post-intervention tests and a control group.

All of the reviews included children – ranging from 2 years up to 19 years of age – in the pre-, primary or secondary school setting. Eighty-six of the reviews (75%) only included

studies conducted in these settings and another 22 reviews (19%) had a majority of studies conducted in the school setting (ranging from 55% to 95% of studies included). Six reviews (5%) had smaller subsets of studies conducted in the school setting (ranging from 6% to 38% of studies included) but reported subgroup analyses results specifically for the school setting. The number of school-based studies included in each review ranged from one to 124 studies, with an overall average of 23 school-based studies. Typically, reviews included between 10 and 19 school-based studies each (Fig. 2).

**Figure 2. Number of school-based studies included in individual reviews<sup>a</sup>**



<sup>a</sup> One review did not report the exact number of school-based studies.

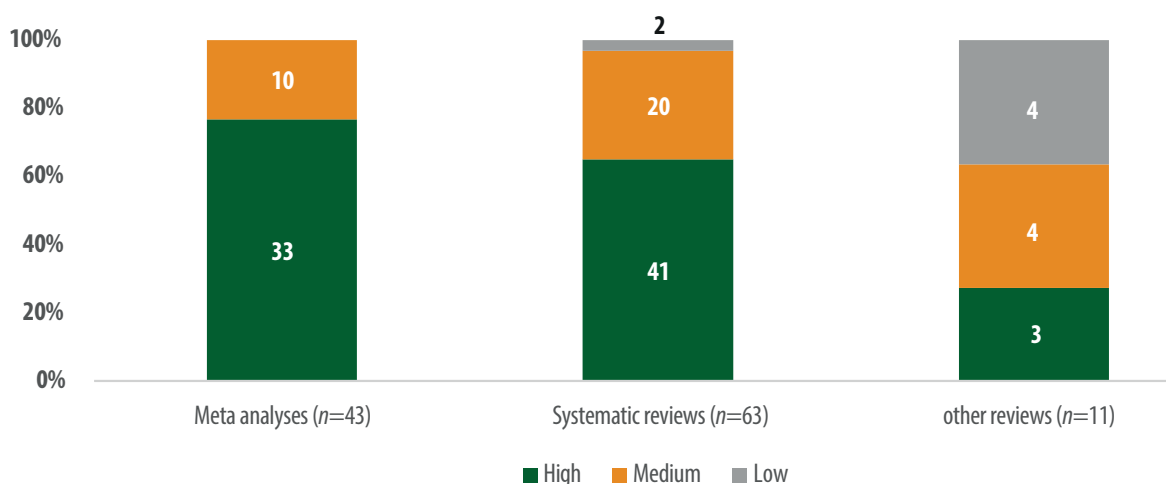
Most reviews did not restrict studies included based upon the country of research.<sup>1</sup> Yet, the vast majority of studies included in the reviews were based in high-income countries, particularly the United States and in Europe. Half of the reviews (58) only included studies from high-income countries. Not more than nine reviews only or largely included studies from low- and middle-income countries, while another four reviews focused on disadvantaged subpopulations in high-income countries.

<sup>1</sup> For example, 10 reviews focused on school interventions in a single country (Canada, China or the United States).

In the assessment of the modified AMSTAR score for review quality, 77 review papers were assessed as high quality, 34 as medium quality and six as low quality. Meta-analyses scored higher than systematic reviews, which in turn scored higher than other review types included (Fig. 3). No particular score distribution pattern emerged based on the geographic or thematic focus of the review papers. Thus, in the subsequent narrative review of evidence by essential criteria, findings of meta-analyses are presented separately from the narrative reviews.



**Figure 3. Assessed modified AMSTAR scores by review type**



**Relevance of interventions and programmes to the NFSI essential criteria**

Most reviews considered studies at the primary (86% of reviews) and/or secondary (75% of reviews) school level, while fewer included studies in preschool establishments (24% of reviews). One hundred and fourteen reviews (97%) considered interventions and programmes related to diet and nutrition, the remaining three reviews included nutrition-relevant outcomes in their analyses of water, sanitation and hygiene (WASH) programmes. Forty-seven reviews (47%) considered multicomponent programmes combining diet and physical activity interventions.

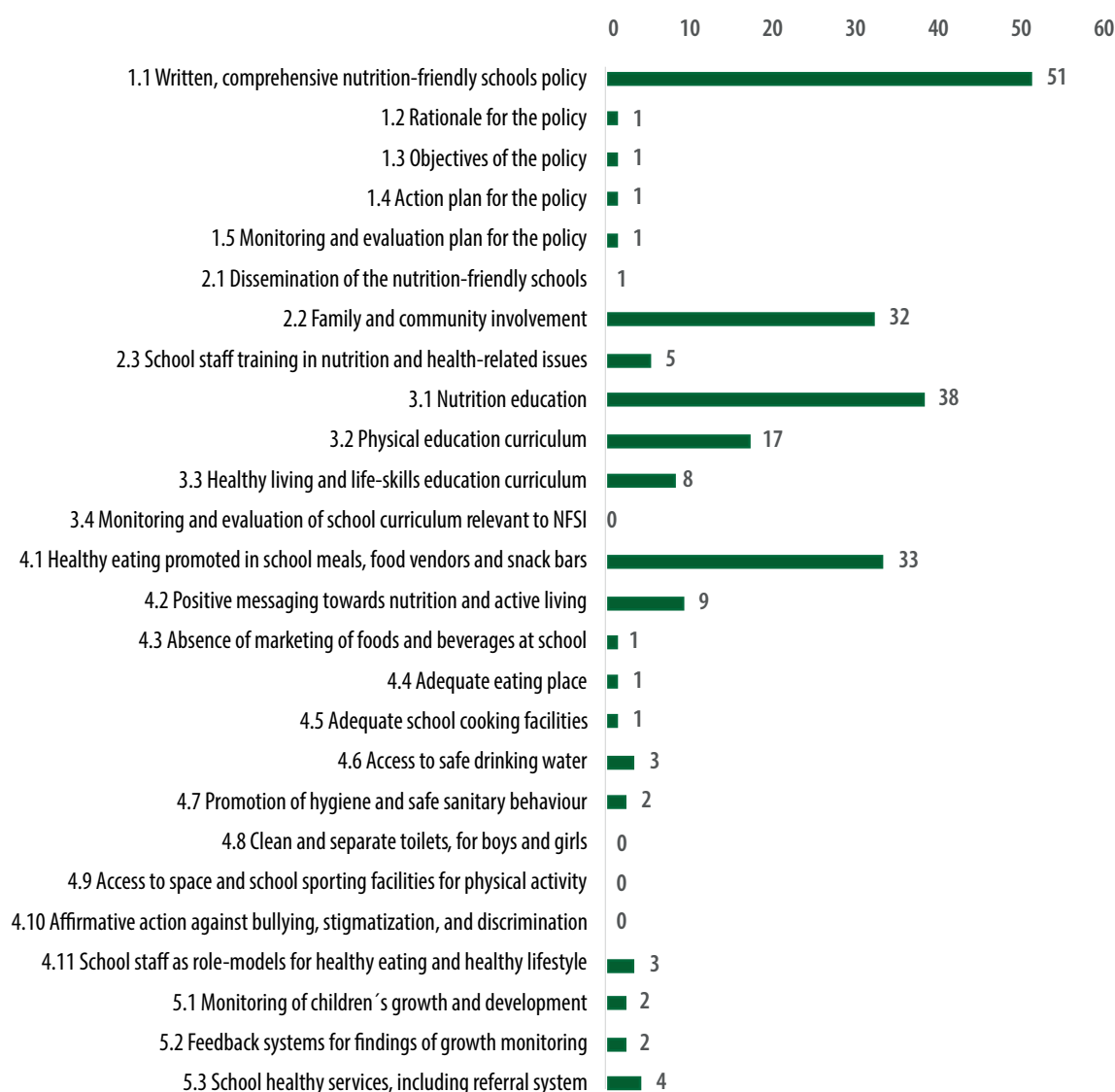
There was wide variation in the number of available published reviews for each component (Fig. 4). In terms of the number of relevant reviews, the majority of the evidence was available for the following criteria: having a written nutrition-friendly schools policy that addresses all five points described in the NFSI framework (essential criterion 1.1); activities for families and community, community involvement and outreach in the area of nutrition and health-related issues (2.2); culturally appropriate and effective nutrition education (3.1); and, school meals, food vendors and snack bars (if present) promoting healthy

eating (4.1). Limited evidence was available for criteria on rationale of the nutrition-friendly schools policy (1.2), objectives of the nutrition-friendly schools policy (1.3), school staff training in nutrition and health-related issues (2.3), age, sex and culturally appropriate physical education curriculum (3.2), healthy living and life-skills education curriculum (3.3), positive messaging towards nutrition and active living (4.2), absence of marketing of foods and beverages at school (4.3), access to safe drinking water (4.6), promotion of hygiene and safe sanitary behaviour (4.7), school staff as role-models in encouraging healthy eating and healthy lifestyle (4.11), regular monitoring of children’s growth and development (5.1), effective feedback systems for parents and children to report findings of regular monitoring (5.2) and supportive school health services, including a referral system (5.3). No evidence was available for criteria on having an action plan for the nutrition-friendly schools policy (1.4), having a monitoring and evaluation plan for the nutrition-friendly schools policy (1.5), dissemination of the NFSI policy (2.1), regular monitoring of school curriculum relevant to NFSI and evaluation of impact of the education against the objectives (3.4), access

to an adequate eating place (4.4), adequate school cooking facilities (4.5), availability of clean and separate toilets for boys and girls (4.8), opportunity for all age groups to access space

and school sporting facilities for physical activity in and outside of curriculum (4.9) and affirmative action against bullying, stigmatization and discrimination (4.10).

**Figure 4. Number of included reviews by relevance to essential criteria**



### **Outcomes reviewed**

The included reviews provided an analysis of a wide range of school-based interventions. Results had a high level of heterogeneity, both in terms of the school-level exposures and the impact on school children. There was also wide heterogeneity between studies in terms of outcome measures. Sixty-eight reviews (58%) considered changes in body mass index (BMI) or other weight-related outcomes in relation to overweight (e.g. body fat percentage, skinfold thickness, waist circumference or prevalence of overweight or obesity), but only five reviews (4%) considered height as a distinct outcome of interest. Sixty reviews (51%) examined the effect of interventions in relation to dietary outcomes (e.g. fat intake, fruit and vegetable consumption), diet behaviour, knowledge or related determinants (e.g. breakfast skipping, purchase, attitudes, self-efficacy, food waste) or the food environment (e.g. availability, access). Eight reviews (7%) reported effectiveness in relation to biochemical measures (e.g. anaemia, blood lipids). A range of other outcomes were considered in the reviews. These related to other health measures (e.g. blood pressure, diarrhoea, infection, mortality), education (e.g. attendance, performance), educational resources (e.g. presentation of foods and diets in text books), family impact (e.g. follow-up action taken by parents) and implementation issues (e.g. compliance with regulations and standards). As explained above, only the nutrition-related outcomes were considered in this review.

### **NARRATIVE SYNTHESIS AND SUMMARY OF THE SYNTHESIZED EVIDENCE**

Evidence from the included reviews was summarized according to its relevance to each of the NFSI components.

#### ***NFSI Component 1: Having a nutrition-friendly schools policy***

The first component of the NFSI is having a nutrition-friendly schools policy. This includes five essential criteria related to the policy's content, in terms of being comprehensive (addressing all other components), having a rationale (addressing the relevant context), having objectives (with timelines and clear milestones), being operationalised in an action plan and having a plan for monitoring and evaluation.

Two types of evidence were identified and reviewed in relation to NFSI essential criterion 1.1:

- the effectiveness of having nutrition-related school policies, and/or
- comprehensive or multicomponent programmes, with or without an explicit underpinning policy.

Some of the evidence touched upon process factors related to the development of school nutrition policies, but no review was identified that examined the effects of having school policy rationale, objectives, action or monitoring and evaluation plans.

## NFSI Component 1: Having a nutrition-friendly schools policy

- Twenty-three meta-analyses and 28 reviews were identified that examined various aspects of comprehensive school nutrition policies and programmes, i.e. NFSI essential criterion 1.1.
- Among this evidence, one systematic review examined the effect of “having a policy” and “it being comprehensive” and found that school-based policies focusing on both the food and beverage and physical activity environments (versus targeting only one of these areas) consistently showed improvements in BMI.
- Furthermore, one meta-analysis and nine systematic reviews examined school food and nutrition-related policies. These typically addressed the school food environment and achieved improvements in outcome measures related to availability, purchasing and/or consumption but less often for weight-related outcomes.
- Another 22 meta-analyses and 18 systematic reviews examined the effect of multicomponent school nutrition interventions, whether underpinned by an explicit policy or not. Most of the reviews analysed the effects of different programme areas (usually diet and physical activity), while fewer analysed the effect of multiple approaches (i.e. curricula, environment, parental involvement).
- Positive effects on weight-related outcomes, biochemical measures, such as blood pressure and blood lipids, and dietary outcomes such as intakes of SSBs or fruits and vegetables, have been shown in studies on comprehensive school nutrition policies and programmes, like the Health Promoting Schools initiative, using multiple approaches (i.e. curricula, environment, parental involvement) or having multiple components (e.g. diet, physical activity).
- Seventeen of the 22 meta-analyses found that comprehensive school nutrition policies and programmes improved various outcomes — such as BMI and other weight-related outcomes, dietary outcomes, blood pressure and blood lipids — and usually more so than single component trials. Improvements in BMI standard mean difference (SMD) ranged from  $< 0.1\text{kg/m}^2$  to  $1.8\text{kg/m}^2$  through school-based programmes.
- Of all the evidence considered under essential criterion 1.1, four systematic reviews focused specifically on low- and middle-income countries or vulnerable populations in high-income countries. These reviews reported positive effects on weight-, diet- or health behaviour-related outcomes from multicomponent school nutrition policies and programmes in these populations.
- One scoping review was identified that could shed some light on essential criteria 1.2 to 1.4. This review examined facilitators and barriers to implementing school nutrition policies.



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*Essential Criterion 1.1: Development of a written nutrition-friendly schools policy that addresses all five components described in this framework, and includes elements described in 1.2 – 1.5*

The first NFSI essential criterion concerns both having a written school nutrition policy and it being comprehensive in addressing all other essential criteria. One 2018 systematic review was identified that examined these aspects together (35). The remaining evidence focused on either having school food and nutrition-related policies (one meta-analysis (36) and nine systematic reviews (37-45)), or implementing comprehensive school food and nutrition-related policies, programmes or interventions (22 meta-analyses (46-67) and 18 systematic reviews (68-85)).

Examining both aspects of “policies” and “comprehensiveness”, Bramante et al. (35) reviewed 33 natural experiments of national and sub-national policies for childhood obesity prevention and control, 24 of which were school-based. They found that school-based policies focusing on both the food/beverage and physical activity environments (versus targeting only one of these areas) consistently showed improvements in BMI, with four out of four such studies achieving favourable outcomes (versus eight out of 14 focusing on the food and beverage environment only). Additionally, the impact on BMI was assessed by the level of government implementing the policy. Among the 26 studies in the United States evaluating government policies, 15 (58%) reported favourable effects on BMI—six of seven (85%) federal policies, three of nine (33%) state/regional policies and six of 10 (60%) local policies.

Regarding the effect of school-based nutrition interventions implemented through policies, one meta-analysis (36) and nine systematic reviews (37-45) were identified. Typically, these addressed the school food environment and achieved

improvements in availability, purchasing and/or consumption, but less often in weight-related outcomes. Most of these reviews did not examine comprehensive policies, but focused on single components that are addressed under other NFSI essential criteria and are therefore discussed in greater detail under those respective sections. For example, a school nutrition policy altering the food and beverage environment would be discussed under NFSI essential criterion 4.1.

In their 2018 systematic review and meta-analysis of 91 studies on different types of school food environment policies, Micha et al. (36) found improved targeted dietary behaviours in children but inconclusive effect on adiposity and metabolic measures. Direct or indirect provision policies, which largely targeted fruit and vegetables, increased consumption of fruits (+0.27 servings/day; 95% CI: +0.17, +0.36), fruit and vegetables (+0.28 servings/day; 95% CI: +0.17, +0.40) and vegetables (+0.04 servings/day; 95% CI: +0.01, +0.08). Standards on foods and drinks sold outside school meal programmes (referred to as competitive foods and beverages) reduced total consumption of SSBs (0.18 servings/day; 95% CI: -0.31, -0.05) and unhealthy snacks (-0.17 servings/day; 95% CI: 0.22, 0.13), as well as in-school consumption of unhealthy snacks (-0.05 servings/day; 95% CI: 0.08, -0.02). School meal standards (mainly lunch) increased fruit intake (+0.76 servings/day; 95% CI: +0.37, +1.16), reduced intake of total fat (-1.49%E; 95% CI: -2.42, -0.57) and saturated fat (0.93%E; 95% CI: 1.15, -0.70), reduced sodium intake (-170 mg/day; 95% CI: -242, -98) and reduced BMI percentile (-1.01; 95% CI: -1.62, -0.39). Positive effects were also seen on increased milk consumption and carbohydrate intake in studies of policies targeting these elements.

In a 2009 systematic review of 27 studies of school food and nutrition policies worldwide targeting the food environment, for example,



through legislating nutrition guidelines, regulating food and beverage availability or intervening on prices, Jaime and Lock (37) found that some policies may improve the food environment and dietary intake but found no evidence for impact on BMI. Similarly, in 2014 Driessen et al. (38) reviewed 18 studies of changes to the school food environment, 11 of which were implemented through policy, and found that all but one study reported positive outcomes. Among the policy studies, positive outcomes were reported by eight of nine studies measuring purchasing and/or consumption and by two of four studies measuring weight-related outcomes. Mayne, Auchincloss and Michael in 2015 (39) reviewed 37 studies evaluating the efficacy of policy and built environment changes on obesity-related outcomes, five of which were school nutrition-related policies at the district, municipal or federal

level to restrict sugary foods and beverages or higher fat foods, and/or increase the availability of milk or fruit and vegetables. Four of these five policy studies reported results in the expected directions (e.g. reducing consumption of energy-dense nutrient-poor food, SSBs, calories or fat, or increasing fruit and vegetable intake) while one study had mixed results. One of the five studies measuring BMI reported mixed results. In 2015, Afshin et al. (40) reviewed the evidence for specific policies to improve dietary habits and reduce cardiovascular and metabolic risk factors, including 76 studies of school procurement policies. Among 26 studies of the effect of restricting unhealthy foods and beverages in schools (e.g. restrictions or bans, nutrient standards for competitive foods in cafeterias, vending machines, school stores, snack bars or snack trucks), interventions appeared generally effective in reducing intake of unhealthy

***Positive effects have been shown in studies on comprehensive school nutrition policies and programmes, like the Health Promoting Schools initiative, using multiple approaches (i.e. curricula, environment, parental)***



competitive foods and beverages and decreasing incidence and prevalence of overweight/obesity, with governmental and school policies being more effective than voluntary programmes.

Chriqui, Pickel and Story in 2014 (41) investigated the effects of state and district competitive food and beverage laws and policies in the school setting in the United States. Overall, 15 of the 24 studies reviewed reported results in the expected direction, especially for outcomes related to availability and access, but less often for outcomes related to purchasing, consumption, dietary intake and/or weight-related outcomes. In another 2018 systematic review of 26 studies on competitive foods and beverage in schools in the United States — 14 of which specifically analysed policies implemented in schools — Sildén (42) concluded that there was a positive association between competitive food and beverages policies and weight-related and/or dietary outcomes, and provided examples where both caloric intake and overweight or obesity had been improved. Also in the United States, Mansfield and Savaiano (43), in 2017, reviewed 31 studies of the U.S. National School Lunch Program nutrition standards resulting from three sequential federal policies. They note that improved food consumption behaviours (increased selection, intake and sales of healthy foods, and decreased plate waste) were reported in 14 of the 19 intervention and longitudinal observation studies. On the other hand, only two of 12 one-time observation studies reported food consumption behaviours meeting target nutrition standards.

In 2019 Von Philipsborn et al. (44) published a Cochrane review of 58 studies aiming to reduce consumption of SSBs, 20 of which were conducted in elementary, middle and high school. In a subanalysis of seven studies of school nutrition standards, five reported reduced SSB intake in children as result of lower availability. In three of these studies, the effect was observed after

implementing a policy-level measure. Likewise, in their 2017 systematic review of 36 school-based interventions aimed at reducing SSB consumption among adolescents, Vézina-Im et al. (45) noted that the 10 studies involving legislative measures or structural changes to the environment (e.g. banning SSBs from school cafeterias or replacing them with healthier alternatives) were the most effective.

Regarding the effect of comprehensive school-based nutrition interventions implemented — whether underpinned by an explicit policy or not — a larger evidence base was identified, notably 22 meta-analyses (46-67) and 18 systematic reviews (68-85). These reviews examined multicomponent interventions combining multiple approaches as described in the FRESH framework and the Health Promoting School approach (e.g. curricula, environment, parental involvement) and/or addressed multiple programme areas (e.g. diet, physical activity, water). Most of the reviews analysed the effects of different programme areas (usually diet and physical activity) in multicomponent interventions where the majority of studies focused on educational approaches.

Of the 22 meta-analyses of multicomponent school nutrition policies and programmes, 17 found that these improved

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BMI and other weight-related outcomes, dietary outcomes, blood pressure and blood lipids in at least one age group of children within schools, and often more so than single component interventions (46-62). Thirteen of these meta-analyses measured weight-related outcomes and demonstrated improvements in BMI SMD ranging from  $< -0.1\text{kg/m}^2$  to  $-1.8\text{kg/m}^2$  through school-based programmes. Four meta-analyses did not find any effect of multicomponent school-based nutrition policies and programmes (63-66), whereas one meta-analysis was unable to pool results, but concluded positively regarding multicomponent programmes (67).

In a 2014 Cochrane review of the effectiveness of the WHO Health Promoting Schools approach, Langford et al. (46) concluded that holistic school-based programmes aligning with (but not necessarily making explicit reference to) all three Health Promoting Schools framework strategies (i.e. curriculum, environment and families and/or communities) can be effective at improving a number of health outcomes in students. The review included 67 RCT studies, of which 34 concerned the effect of diet and/or physical activity interventions on nutrition-related outcomes. Meta-analysis on these 34 multi-

approached studies demonstrated significant improvements in BMI from three physical activity only studies (MD:  $-0.38\text{kg/m}^2$ ; 95% CI:  $-0.73, -0.03$ ), in BMI z-score from one physical activity only study (MD:  $-0.47$ ; 95% CI:  $-0.69, -0.25$ ), and in fruit

and vegetable intake from nine nutrition only studies (SMD:  $+0.15$ ; 95% CI:  $+0.02, +0.29$ ). However, no significant improvements were found for combined nutrition and physical activity interventions or on other nutrition-related outcomes (e.g. fat intake).

In another 2011 Cochrane review of 55 long- and short-term childhood obesity prevention programme studies by Waters et al. (47), 43 included an educational setting, and this was also identified as the most effective setting. Interventions were mostly delivered through educational approaches, but some also addressed the environment and/or employed school health nurses. It included a meta-analysis of 37 studies covering 27 946 children, in which the greatest overall effect on BMI or BMI z-score was found for combined physical activity and dietary interventions (SMD:  $-0.18$ ; 95% CI:  $-0.27, -0.09$ ) versus physical activity alone (SMD:  $-0.11$ ; 95% CI:  $-0.19, -0.02$ ), while there was no significant effect of diet alone. Updating the paper by Waters et al (47), Peirson et al. in 2015 (48) reviewed 90 studies, 71 of which were school-based and largely focused on, but not restricted to, behavioural interventions. Like Waters et al. in 2011 (47), they found that schools were the most effective setting, showing significant reductions in BMI or BMI z-score (SMD:  $-0.09$ ; 95% CI:  $-0.17, -0.03$ ). In the overall meta-analysis of 76 studies involving 56 342 children, small but significant reductions were observed in BMI or BMI z-score (SMD:  $-0.07$ ; 95% CI:  $-0.10, -0.03$ ), in BMI (MD:  $-0.09\text{kg/m}^2$ ; 95% CI:  $-0.16, -0.03$ ), and in the prevalence of overweight and obesity (RR: 0.94; 95% CI: 0.89, 0.99). Significant reductions in BMI or BMI z-score were found for diet and exercise combined (SMD:  $-0.10$ ; 95% CI:  $-0.17, -0.03$ ), but not for either component alone. In a subsequent update of the original analysis by Waters et al. (47), Gori et al. (49) in 2017 did a review and meta-analysis of 72 studies in overweight or obese primary school age children, 47 of which were school-based. Interventions typically took an educational approach, though some studies also changed the environment, engaged school health nurses and/or involved parents. In this update significant results were found for combined diet and physical activity interventions in children 6-12 years (mean BMI



standard deviation score (BMI-SDS): -0.13; 95% CI: -0.19, -0.06) as well as physical activity alone (mean BMI-SDS: -0.11; 95% CI: 0.16, -0.06, 14 studies). However, the largest effect on BMI-SDS was from combined school-based diet and physical activity interventions with a parental involvement component (mean BMI-SDS: -0.15; 95% CI: -0.21, -0.03). No other significant results were found for any intervention or setting combination or other age groups.

In a meta-analysis of 52 school-based and after-school diet, physical activity and/or lifestyle interventions delivered through educational or other approaches involving 28 236 children 5–18 years of age, Vasques et al. in 2014 (50) found that the combined interventions were more effective than single interventions in reducing children's BMI. Those combining diet and physical activity were the most effective with a medium effect size ( $r = 0.148$ ) compared to small effect sizes for any other intervention type or combination. In a 2012 meta-analysis of 68 single- and multicomponent obesity prevention studies among children and adults, Luckner, Moss and Gericke (51) found significant reduction in BMI among children and adolescents in six school-based studies combining educational activities and non-educational activities to increase physical activity and improve nutrition (MD:  $-0.1 \text{ kg/m}^2$ ; 95% CI: -0.17, -0.04). However, larger, significant BMI effect sizes were seen for reduced TV viewing and for physical activity. Other intervention combinations had too high heterogeneity or showed no statistically significant difference in outcomes.

In a 2013 meta-analysis of 32 school-based obesity prevention programme RCT studies involving 52 109 children 5-18 years of age, Sobol-Goldberg, Rabinowitz and Gross (52) found an overall significant reduction in BMI (SMD: -0.076; 95% CI: -0.123, -0.028). Meta-regression analyses showed a significant linear hierarchy of studies based on their design. The largest effects were

from six comprehensive multicomponent and multiapproached programmes of a duration of 1 year or longer and including education on nutrition and physical activity, modification to the environment and parental involvement (SMD: -0.151; 95% CI: -0.334, -0.031). In 2012 Friedrich, Schuch and Wagner (53) reported a meta-analysis of 23 school-based studies. All studies included an educational approach and seven studies also had an environmental component. The authors found that combined physical activity and nutrition education significantly improved BMI outcomes (SMD: -0.37; 95% CI: -0.63, -0.12), whereas neither component alone gave any significant result. Katz et al. in 2008 (54) reviewed 19 school-based obesity prevention studies delivered through multiple approaches (e.g. information sessions, practical hands-on skill building, teacher training, school cafeteria modifications) and with a minimum duration of 6 months. Results from the meta-analysis of eight studies of combined nutrition and physical activity interventions involving 10 752 children 3-18 years of age showed significant reduction of body weight in children (SMD: -0.29; 95% CI: -0.45, -0.14). This was similar to the effect of a single nutrition intervention (SMD: -0.39; 95% CI: -0.56, -0.23) and a single TV reduction intervention (SMD: -0.35; 95% CI: -0.63, -0.06), whereas other single component interventions were not found to be effective.

In a 2012 meta-analysis of 43 studies on school-based interventions covering 36 579 children 18 years or younger, Lavelle, Mackay and Pell (55) found that interventions combining physical activity with nutrition were associated with significant improvements in BMI (MD:  $-0.17 \text{ kg/m}^2$ ; 95% CI: -0.29, -0.06). The majority of studies applied educational approaches and only a few modified the environment. Overall, interventions targeted at overweight or obese children were more effective in reducing BMI than those delivered to all children. Similarly, in China in 2017, Feng et al. (56) reviewed 76 school-based obesity intervention studies

covering 72 620 children 6-19 years of age. The majority of the interventions were multicomponent applying multiple approaches such as education, weight monitoring and counselling and/or school policies. They found that the comprehensive interventions involving physical activity and health education had the largest effect on BMI in both treatment studies (SMD: -1.80; 95% CI: -2.15, -1.44) and prevention studies (SMD: 0.19; 95% CI: -0.27, -0.11). Among the prevention studies targeting all children, 19 of 27 multicomponent interventions (70.4%) were effective versus two out of nine single component interventions (22.2%).

In 2019, Brown et al. (57) conducted a Cochrane systematic review and meta-analysis of 153 obesity prevention studies applying various approaches (e.g. educational, environmental, policy, parental involvement), of which 91 were school-based and 22 took place in kindergartens or preschools. In children aged 6-12 years in the school setting, significant effect was found on BMI z-score from combined diet and physical activity interventions (-0.04; 95% CI: -0.08, -0.01). In children of 13-18 years of age, significant effect was found on BMI z-score and BMI from

physical activity alone. No effect was found from any combination of interventions in children under five years of age. They also pooled results from studies that compared different interventions against each other (e.g. diet alone vs combined diet/physical activity) and all such analyses did not find differences in impact.

In the United States, Wang et al. (58) in 2013 reviewed 124 obesity prevention interventions in multiple settings, 104 of which were conducted in schools. Over half of the school-based interventions reported statistically significant beneficial intervention effects in at least one weight related outcome (BMI, BMI z-score, prevalence of overweight and obesity, waist circumference, skinfold thickness and percent body fat). High strength of evidence was found for combined diet and physical activity interventions with a home and community component and moderate strength of evidence for combined interventions with either a home or a community component. Comprehensive interventions addressing the environment (e.g. modified food and beverage items offered in school cafeteria, or structural changes in school physical activity) and individuals' knowledge and attitude





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(e.g. nutrition education) were more likely to be successful than those addressing either one alone. Meta-analyses of school-based studies combining diet and physical activity found improved BMI z-score (-0.08; 95% CI: -0.14, -0.02,  $P = 0.009$ ) from four studies and improved BMI (-0.32 kg/m<sup>2</sup>; 95% CI: -0.49, -0.16,  $P < 0.001$ ) from seven studies.

Beneficial effects of school-based interventions were also observed for outcomes other than BMI or weight. Evans et al. (59) reported a 2012 systematic review and meta-analysis of 27 studies to increase fruit and vegetable intake using multiple approaches such as nutrition education, parental involvement, fruit and vegetable provision, food preparation and/or tasting, where the majority of studies were multicomponent programmes. In a meta-analysis of 21 of the 27 studies they found that total fruit and vegetable intake increased (+0.25 portions/day; 95% CI: +0.06, +0.43), mainly due to increases in fruit consumption. The authors noted that multicomponent programmes tended to result in larger improvements while single component interventions, including free and subsidized fruit and vegetable distribution schemes, tended to be less effective although there were too few studies included to make firm conclusions. In another meta-analysis of school-based interventions to promote fruit and vegetable consumption, Howerton et al. (60), in 2007, reviewed seven studies on classroom-based activities coupled with other strategies, such as family involvement or food service changes, and involving 8 156 children aged 7–12 years of age. They found increased fruit and vegetable consumption in the intervention group compared to the control group (+0.45 servings; 95% CI: +0.33, +0.59).

In a 2014 meta-analysis of 23 studies of child obesity prevention programmes, Cai et al. (61) found that combined diet and physical activity interventions mainly delivered through educational approaches, although in

some instances additionally by modifying the environment, most of which were implemented in the school setting, led to a significant reduction in both systolic blood pressure (SBP) (WMD -2.11 mmHg, 95% CI: -3.19, -1.03) and diastolic blood pressure (DBP) (WMD: -1.51 mmHg; 95% CI: 2.55, -0.47), but not for either component alone. In a similar meta-analysis of 17 child obesity prevention studies focusing on blood lipids, Cai et al. (62), found in 2014 overall significant improvements in low-density lipoprotein-cholesterol (LDL-C) and high-density lipoprotein-cholesterol (HDL-C), but not total cholesterol and triglyceride. The programmes that combined diet and physical activity led to larger but non-significant improvements in HDL-C and total cholesterol than the single component programmes, and to significant improvements in LDL-C (WMD: 8.49 mg/dL; 95% CI: -12.77, -4.21) which was larger than the programmes focusing on physical activity alone (WMD: -2.67 mg/dL; 95% CI: -4.30, -1.03) but lower than the programmes focusing on diet alone (WMD: -17.59 mg/dL; 95% CI: -25.58, -9.60).

In contrast, four meta-analyses did not find positive effects of school-based multicomponent nutrition policies or programmes (63–66). Two of these were 2017 reviews of obesity treatment studies using behavioural change interventions addressing diet and physical activity (63, 64). Overall positive effects in analyses of all settings were found in both reviews, but not in subgroup analyses of the school setting where studies were low in numbers. Mead et al. (63) found overall positive effect on BMI, BMI z-score and weight change when pooling the results from 70 studies in any setting, but in subgroup analyses based on setting, the two school-based studies included in the meta analyses did not show significant effect on weight, BMI or BMI z-score. Likewise, Al-Khudairy et al. (64) found significant positive effect on BMI, BMI z-score and weight change among overweight and obese adolescents aged

12-17 years when pooling results from 44 studies in any setting. However, the effects on BMI in seven school-based studies and on BMI z-score in two school-based studies were positive but not significant.

Two other meta-analyses found larger effects of single component programmes compared to multicomponent programmes. Hung et al. (65) in 2015 did not find strong evidence of school-based childhood obesity prevention programmes in a meta-analysis of 27 studies. Moreover, single component programmes resulted in larger — although small — effect than multicomponent programmes. Likewise, in a meta-analysis of 38 studies on school-based combined physical activity and nutritional education interventions, Guerra et al. (66) in 2014 did not find significant reductions in BMI, although nutrition education alone was found to be effective.

Finally, one 2013 meta-analysis of 21 studies of school-based diet and physical activity interventions by Williams et al. was unable to pool results from the six programmes that combined diet and physical activity programmes due to high heterogeneity (67). However, the authors noted that these programmes demonstrated promising results, particularly those which involved stakeholder involvement and engagement with families.

In addition to these meta-analyses, 18 systematic reviews were identified as relevant to essential criterion 1.1. Of these reviews, 15 identified benefits of multicomponent programmes on weight-related and/or dietary outcomes (68-82), while three reviews did not find improved outcomes as a result of multicomponent nutrition policies or programmes (83-85). Four of the reviews considered disadvantaged populations (69-71, 76, 82).

Four of the 15 reviews identifying benefits of multicomponent programmes, considered both multiple approaches and programme



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components. De Bourdeaudhuij et al. (68) in 2011 conducted a systematic review of 11 school-based obesity prevention interventions and identified five studies on promotion of physical activity and nutrition to adolescents through schools. They found moderate evidence that multicomponent interventions focusing on healthy diets and physical activity habits, and combining an educational with an environmental component, had a positive impact upon weight-related measures in adolescent girls. These programmes were more effective than focusing on education alone. In primary-school-age children, only one of four multicomponent interventions improved anthropometric outcomes, but they still showed more favourable results than those only using education.

In low- and middle-income countries, Verstraeten et al. (69) conducted a review in 2012 of 15 studies targeting physical activity and/or dietary behaviour for the primary prevention of obesity in children and adolescents aged 6–18 years. While neither of the two dietary behaviour interventions had a significant effect on BMI, four out of the five physical activity intervention studies did. However, the largest effect size on BMI came from two high-quality studies of combined diet and physical activity interventions using integrated curriculum delivered by teachers and accompanied by nutrition education of parents. In a 2019 scoping review of 15 preschool interventions in low socioeconomic settings in high-income countries, Luybli, Schmillen and Sotos-Prieto (70) found that both successful and inconclusive studies included multiple components or approaches, such as nutrition, physical activity and parental involvement. The authors concluded that obesity outcomes can be targeted in low socioeconomic settings through school interventions with a multicomponent approach, but that further research is needed regarding the appropriate interventions. In elementary schools in the United States with large minority populations, Johnson, Weed and Touger-Decker (71) found in

2012 that all seven multicomponent programme studies included reported some benefits in health behaviours and/or anthropometric measures, five of which reported a positive benefit on overweight and/or adiposity. The authors noted that effectiveness was greater when programme objectives were specific, implemented across the school environments, extended into the community and were culturally relevant.

Another eight of the 15 reviews identifying benefits of multicomponent programmes, considered studies employing multiple approaches. In a 2013 systematic review of 19 studies of nutrition promotion programmes using a full or partial WHO Health Promoting Schools approach, Wang and Stewart (72) found that such approaches may improve children's diet and nutrition knowledge, attitude and skills, and behaviour. Improvements observed included: increased consumption of high-fibre foods, healthier snacks, water, milk, fruit and vegetables; reduced breakfast skipping; and reduced consumption of nutrient-poor foods including high-fat foods and sweet drinks. In another systematic review of 17 school-based childhood obesity prevention studies, Brown et al. (73) found in 2016 that multifaceted programmes lasting between 6 and 12 months and involving multiple environmental, educational and physical strategies were most likely to improve BMI and BMI z-score. Similarly, in 2016, Meiklejohn, Ryan and Palermo (74) reviewed 11 studies on school-based nutrition education coupled with complementary strategies such as parental involvement or school food policies and found significant improvements in BMI or dietary intake in 10 of these studies.

In a 2012 series of systematic reviews on various aspects of nutrition education in countries with a high or very high human development index, the United States Department of Agriculture (USDA) (75) conducted a systematic review of

five school-based studies combining nutrition education with changes to the school food environment. They found that combining changes to the school food environment with nutrition education was effective for improving children and adolescents' dietary intake (e.g. fruit and vegetable intake, fish consumption). In two studies the combined approach was more effective, in one study it was more effective in boys only and in two studies both approaches were effective. In 2018 Colley et al. (76) reviewed nine multicomponent school food programme studies in Canada, many of which targeted disadvantaged children. All studies included school food provision, and eight of them also included other interventions such as policy, education, family and community involvement. They found that these programmes were positively associated with children's development of nutrition knowledge in four out of six studies which measured it, in dietary behaviour and food preferences in all seven studies measuring this and in intake of healthy foods in six out of eight studies which assessed intakes.

De Sa and Lock (77) reported a 2008 systematic review of 30 studies of school-based interventions to promote fruit and vegetable intake using multiple approaches — such as free or subsidized fruit and vegetables, classroom activities, school policy, parental involvement and/or modification to the school food service — and where the majority of studies were multicomponent. Overall, 22 of the 30 studies (> 70%) increased fruit and vegetable intake. In another systematic review of 14 studies to increase fruit and vegetable consumption, Aloia et al. (78) in 2016 found that 8 out of the 13 multicomponent studies that included parental involvement, teacher involvement, nutrition education, food service and school gardens showed significant increases in consumption of fruit and vegetables among school children. In 2006, Knai et al. (79) also reviewed interventions to promote fruit and vegetable consumption

in children, using multiple approaches such as classroom- and non-classroom-based education, changes to the environment, parental involvement and/or training for staff. Of the 15 studies reviewed, 14 were conducted in the school setting and 10 had a significant positive effect on fruit and vegetable consumption. The authors noted that the strongest evidence was found for interventions combining multiple approaches.

Finally, three of the 15 reviews identifying benefits of multicomponent programmes, considered studies addressing multiple programme areas. In a 2018 systematic review of 56 studies in various settings — 47 of which were conducted in schools, preschools or after-school — Bleich et al. (80) found that all 17 of the 24 school-based RCTs that reported positive results in weight-related outcomes (BMI, BMI z-score, BMI percentile, body fat percentage, skinfold thickness, waist circumference or prevalence of overweight or obesity) used combined diet and physical activity interventions. Brown and Summerbell in 2009 (81) investigated the effectiveness of 38 school-based obesity prevention interventions and found that nine of 20 (45%) studies on combined diet and physical activity interventions significantly improved BMI, which was better than for either component alone. In ethnic minority school children aged 10-14 years, in 2010 Stevens et al. (82) reviewed eight studies of diet and physical activity obesity prevention programmes and found improvements in various dietary outcomes including decreased consumption of high-fat and other high-calorie foods and soft drinks, as well as increased consumption of fruits and vegetables.

On the other hand, three systematic reviews did not find multicomponent



school-based programmes addressing multiple programme areas to be more effective than single component programmes. In a 2006 systematic review of 25 largely school-based obesity prevention studies focusing on diet and/or physical activity, Doak et al. (83) compared features of 17 studies that were effective in improving outcomes related to height/weight and/or skinfolds against features of the eight non-effective interventions. They found that a slightly smaller proportion of the effective interventions vs. the non-effective interventions intervened on both diet and activity (82% of studies vs. 88% of studies), included activities outside school as part of the intervention (67% vs. 88%), targeted the physical environment (24% vs. 25%), required active participation of children (82% vs. 100%) and actively involved parents (47% vs. 57%) or the broader community (6% vs. 14%). The effective interventions were, however, more often considered sustainable in terms of being accepted by the school community or financially viable (94% vs. 88%). Likewise, in 2007 Lissau (84) reviewed 14 school-based obesity prevention studies in the school arena and found that half of the studies had an effect on either overweight or obesity. However, only two of the six multicomponent studies that included nutrition/diet were effective.

In a 2008 systematic review of 14 school-based obesity prevention programmes of at least 6 months duration, Kropski, Keckley and Jensen (85) did not find that combined diet and physical activity interventions were more effective than interventions with either component alone. Significant reduction in overweight was reported in at least one subgroup in five of 11 combined studies and one of two physical activity studies, whereas the sole nutrition only study reported reduction in overweight but without indicating significance.

#### *Essential Criteria 1.2 Rationale, 1.3 Objectives, 1.4 Action plan, and 1.5 Monitoring and evaluation plan*

No systematic reviews were identified that specifically examined the effects of having school policy rationale, objectives, action or monitoring and evaluation plans. However, McIsaac et al. (86) conducted a 2019 scoping review of 59 studies and identified facilitators and barriers to the implementation of school nutrition policies and derived a set of opportunities for action to make such policies more successful. Some of these factors are relevant to the elements described in essential criteria 1.2-1.5. According to the review, the opportunities for action were, first, to provide macro-level support to encourage policy implementation. This was analysed in 41 studies in terms of clarity of policy execution and policy language, training support and resources for school staff, monitoring and enforcement of the policies and communication between schools, policy-makers and other stakeholders. The second opportunity identified was to address the financial implications of healthy food access, and this was included in 39 studies in terms of access to and procurement of fruit and vegetables and other nutritious options that often have higher costs, but generate more revenue and higher profit. This can lead to trade-offs between keeping costs low for students and families and generating sufficient income from cafeterias and canteens, while also eliminating historic practices in schools of using unhealthy foods to raise funds. Third, aligning nutrition and core school priorities was identified as an opportunity for action; this was examined in 20 studies in terms of competing priorities and demands on, for example, academic assessment that make it difficult for schools to implement nutrition-related changes and the time-consuming nature of policy implementation and partner involvement. Fourth, developing a common purpose and responsibility among stakeholders, which was included in 45 studies in terms of



school climate, values, opinions and cultural norms related to food within schools, at home or in the communities. These cultural norms included the perceived student preference for less healthy foods, the school capacity for leadership and coordination and engagement of parents. A fifth area of opportunity was recognition of school and community characteristics, which was examined in 33 studies in terms of contextualising the policies to school location and demographics, addressing issues of poverty and food insecurity that may lead to inequity, school infrastructure (such as cafeterias or gardens), wider infrastructure and the access to competitive foods from the school surroundings or at home.

### ***NFSI component 2: Enhancing awareness and capacity building of the school community***

The NFSI component 2 entails awareness-raising and capacity-building. The essential criteria cover the dissemination of the nutrition-friendly schools policy, ensuring the active involvement of families and communities in promoting healthy diets and training school health staff on nutrition and health-related issues.

Numerous reviews were identified examining the involvement of parents in school nutrition programmes and activities, there were also some that considered staff training related to school nutrition, while no evidence was identified for dissemination of the school nutrition policy.



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## NFSI component 2: Enhancing awareness and capacity building of the school community

- Fourteen meta-analyses and 18 reviews were identified relevant to essential criterion 2.2, examining family and community involvement in school nutrition programmes.
- All five meta-analyses that compared studies with or without parental involvement found better results in BMI and blood pressure among the studies with parental involvement. Parental involvement was identified as a moderating factor leading to greater success in three of these meta-analyses.
- Five of the eight meta-analyses that examined studies or sub-sets of studies with a parental involvement component, but without comparison to no parental involvement, found significant results in BMI and other weight-related outcomes, as well as fruit and vegetable consumption.
- Eight out of 11 reviews analysing the effect of parental involvement pointed to family or community involvement as a factor leading to positive outcomes in terms of weight-related outcomes, fruit and vegetable consumption or NCD risk factors.
- Direct parental involvement methods where parents are actively participating (e.g. attendance of educational or counselling sessions) more often led to changes in dietary outcomes than indirect methods where parents are passive recipients of information (e.g. newsletters, tip sheets, invitations to attend events).
- Parental involvement was identified as particularly important for the younger age groups of children.
- Only one scoping review considered under criterion 2.2 focused on disadvantaged populations in higher-income countries, which noted that parental involvement is important in preschool multicomponent interventions in low socioeconomic settings.
- Five systematic reviews were identified relevant to essential criterion 2.3, which examined aspects of school staff training on nutrition or recognized it as a success factor. For example, studies that trained existing teachers or engaged nutrition and physical activity experts in the implementation were more likely to succeed.
- Two Cochrane reviews found insufficient evidence to draw any firm conclusions regarding effective strategies to improve implementation or staff knowledge, attitudes and skill, although significant improvements frequently were reported in primary studies.
- Working with teachers to develop programmes and providing ongoing training, support and communication can have moderate positive results in terms of reducing BMI, enhancing physical activity and improving fruit and vegetable consumption.
- A body of research on school-based nutrition interventions has included staff training as part of its work, but additional analyses are needed to unravel the effects of this component from other components of the intervention.

### *Essential criterion 2.1: Dissemination of the Nutrition-Friendly Schools Policy*

No specific evidence was identified for essential criterion 2.1. The dissemination of school policies was not disentangled from other programme elements in the synthesized evidence on school policies reviewed under NFSI component 1.

### *Essential criterion 2.2: Activities for families and community, community involvement and outreach in the area of nutrition and health-related issues*

Both the FRESH Framework and the WHO Health Promoting Schools approach recommend that health and well-being are integrated into every aspect of school life, which is why families and communities should be included in school-based health promotion. They may play an important role in prioritizing and implementing various components of the intervention and ensure that health promotion activities extend beyond the school gates and into other areas of a child's life. Parents and caregivers are critical in ensuring that improved behaviours and practices resulting from school-based interventions are sustained and not hindered at household level.

Fourteen meta-analyses (46, 49, 50, 52, 54, 58, 67, 87-93) and 18 reviews (70, 74, 78-80, 83, 94-105) were identified that examined the involvement of parents in school-based nutrition programmes.

Among the 14 meta-analyses, five compared studies with or without such involvement (50, 52, 87-89), eight investigated studies with a parent or community involvement component included in all or a subset of studies (46, 49, 54, 58, 90-93), while one was unable to pool results for this aspect specifically (67). Two of these meta-analyses had parental or community involvement as a main objective (87, 90) and three compared the effect of different levels of involvement (50, 87, 90).

All five meta-analyses that compared studies with or without parental involvement found better results in BMI and blood pressure among the studies with parental involvement. Niemeier, Hektner and Enger (87) conducted a 2012 meta-analysis of 36 RCTs in multiple settings to compare the effectiveness of nutrition and/or physical activity interventions with and without parent participation (e.g. special lessons, complementary sessions, handbooks, counselling or meetings for parents). Among the 17 preventive studies, which were largely school-based, parent participation significantly contributed to prevention of BMI increase compared to those with no such component (weighted average differences in effect sizes 0.30,  $P = 0.027$ ). Moreover, significant differences existed among levels of parent participation ( $P < 0.05$ ) and intervention duration ( $P = 0.006$ ), and the linear combination of parent participation and intervention duration significantly predicted intervention effectiveness ( $P = 0.001$ ). In another meta-analysis of 11 school-based obesity interventions involving school health nurses, Schroeder, Travers and Smaldone (88) in 2016 found in a subgroup analysis of six studies that, while both were effective, the three studies with parental involvement (e.g. participating in counselling, consultations or education) resulted in larger decreases in mean BMI ( $-0.72 \text{ kg/m}^2$ ; 95% CI:  $-1.42, -0.01$ ) than the three studies without this component ( $-0.06 \text{ kg/m}^2$ ; 95% CI:  $-0.11, -0.01$ ).

Parental involvement was identified as a moderating factor leading to greater success in three of these five meta-analyses. Oosterhoff, Joore and Ferreira (89) conducted a 2016 meta-analysis of 85 RCTs on interventions to improve healthy eating and/or physical activity among children aged 4–11 years, and 53 of these had a parental involvement component (newsletters, information sessions and/or participation in homework tasks for children). The meta-analysis



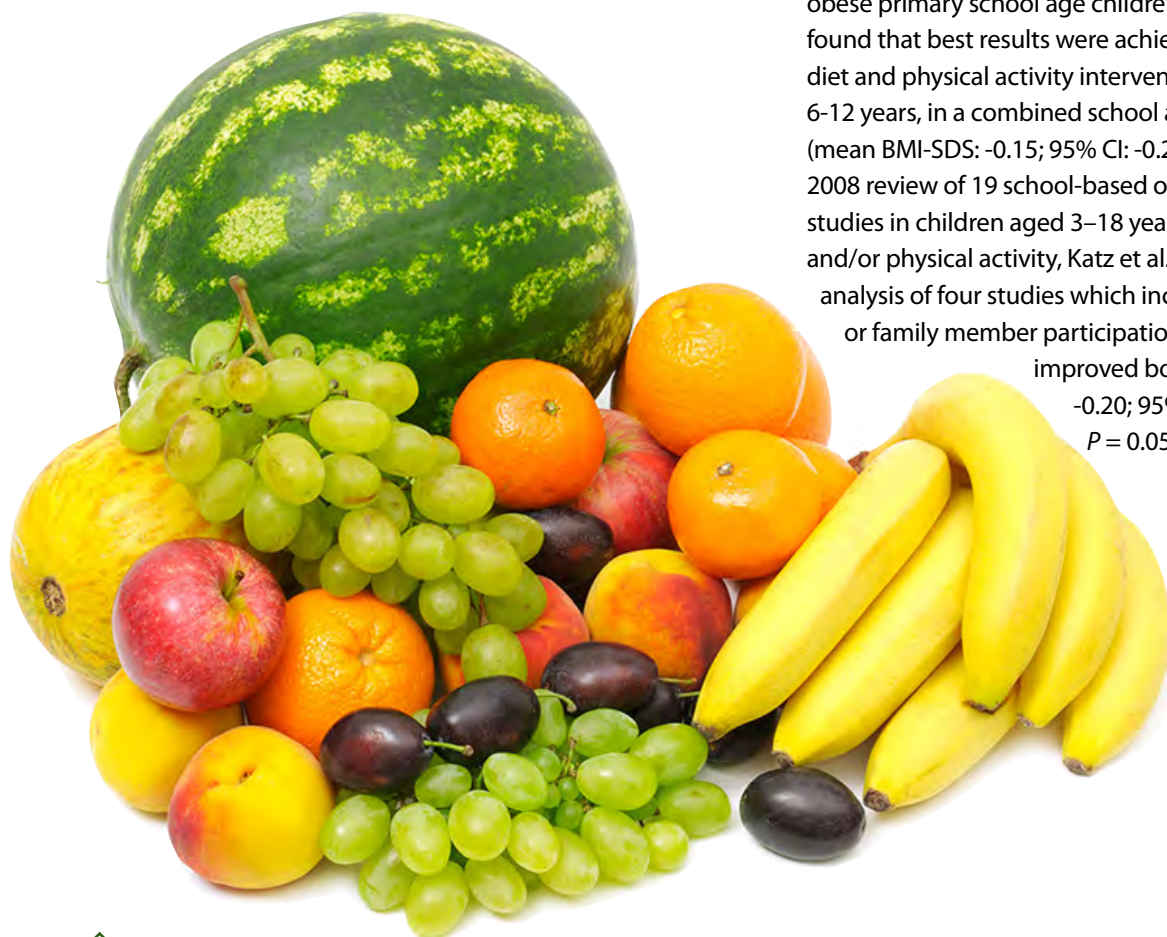
found significant beneficial pooled effect sizes in BMI (-0.072; 95% CI: -0.106, -0.038), SBP (-0.183; 95% CI: -0.288; -0.078) and DBP (-0.071; 95% CI: -0.185, 0.044). Using a magnitude of SDs around the BMI mean values (on average 3.1 kg/m<sup>2</sup>), the authors noted that the reduction in BMI translated to approximately -0.22 kg/m<sup>2</sup>. Multivariable meta-regression analyses of moderators showed that parental involvement significantly improved the beneficial effects on BMI and SBP, but for BMI these only explained a third of the variation and the authors call for further comprehensive analyses of moderating factors. In the 2014 meta-analysis of 52 school-based and after-school studies involving 28 236 children and adolescents described under essential criterion 1.1, Vasques et al. (50) found that any level of parental involvement had significant and positive effects, with an increasing effect size for increasing level of parental involvement:

no involvement ( $r = 0.047$ ), minimal ( $r = 0.057$ ), moderate ( $r = 0.082$ ) and high ( $r = 0.094$ ), with significant differences between groups ( $P = 0.001$ ). In the 2013 meta-analysis of 32 school-based obesity prevention interventions covering 52 109 children aged 5–18 years also described under essential criterion 1.1, Sobol-Goldberg, Rabinowitz and Gross (52) found significant reduction of BMI of all age groups (SMD: -0.076; 95% CI: -0.123, -0.028) and in children alone (SMD: -0.104; 95% CI: -0.195, -0.01) albeit not in adolescents. A meta-regression analysis based on key characteristics of intervention programmes showed the largest effects for comprehensive programmes with parental support.

Five of the eight meta-analyses that examined effects in studies or sub-sets of studies with a parental involvement component without

comparison to studies that did not involve parents, found significant results in BMI and other weight-related outcomes, as well as fruit and vegetable consumption. In a meta-analysis of 16 obesity prevention studies with different levels of community engagement among school-aged children in the United States, Krishnaswami et al. (90) found in 2012 that overall community engagement performance scores were positively correlated with diet, physical activity and weight-related outcomes ( $r: 0.66$ ; 95% CI: 0.25, 0.88). The two studies with the highest community engagement performance scores achieved the highest outcome performance. In another meta-analysis Nathan et al. (91), in 2019, examined 10 school- or centre-based studies to improve the healthiness of foods provided from home and found a moderate increase in provision of vegetables (SMD: 0.40; 95% CI: 0.16, 0.64,  $P = 0.001$ ),

but not fruit, from four of the 10 studies. Of the studies not included in the meta-analysis, mixed results were observed for foods and beverages brought from home, though two out of three studies reported significant effect on consumption of fruits and vegetables. While all included studies in the review incorporated a parent component, many simply relied on passive information dissemination strategies (e.g. pamphlets, newsletters). The other three meta-analyses were described in essential criterion 1.1 (46, 49, 54). The 2014 meta-analysis by Langford et al. (46) of studies of interventions following the WHO Health Promoting Schools framework (i.e. including a parent/family involvement component) found positive intervention effects in terms of reducing BMI, enhancing physical activity and improving fruit and vegetable consumption. In the 2017 meta-analysis of 72 studies among overweight or obese primary school age children, Gori et al. (49) found that best results were achieved for combined diet and physical activity interventions in children, 6-12 years, in a combined school and family setting (mean BMI-SDS: -0.15; 95% CI: -0.21, -0.03). In the 2008 review of 19 school-based obesity prevention studies in children aged 3-18 years focusing on diet and/or physical activity, Katz et al. (54) did a meta-analysis of four studies which included parent or family member participation and found improved body weight (SMD: -0.20; 95% CI: -0.41, 0.00;  $P = 0.05$ ).



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On the other hand, three meta-analyses found positive but insignificant effects of studies with a parental involvement component. In a 2015 systematic review and meta-analysis of 49 school-based studies of children aged 5–12 years ( $n = 38\,001$ ), Dudley, Cotton and Peralta (92) examined different teaching strategy approaches, such as enhanced curriculum, cross-curricula, parental involvement, experimental, contingent reinforcement, literary abstraction and games- or web-based approaches. They found that most of the teaching strategies led to positive changes in healthy eating behaviours (e.g. fruit and vegetable consumption, reduced sugar consumption), but in the pooled results, fewer strategies had mean effect sizes over 0.4 ( $M_d > 0.4$ ), above which was considered the cut-off for positive effect in this review. The 10 studies which included a parental involvement strategy generally led to good results in individual studies (91% positive outcomes), but the pooled mean effect size ( $M_d = 0.39$ ) was just below the cut-off for significant positive effect. Similarly, Wang et al. (93) conducted a systematic review and meta-analysis in 2015 of 139 studies of obesity prevention strategies targeting healthy diets and/or physical activity, 115 of which were conducted in the school setting. Statistically significant and beneficial effects were reported by about half of the school-based studies, especially those with a home involvement component. However, in the meta-analysis of eight studies of school-based interventions with a home component, the weighted mean BMI difference was beneficial but not significant. In the 2013 comparative effectiveness review and meta-analysis of 124 obesity prevention interventions in the United States described under essential criterion 1.1, Wang et al. (58) found greatest strength of evidence for the benefits of school-based approaches from physical activity alone with a home component and combined diet and physical activity with home and community components. However, in the meta-analyses, only the combined diet and physical activity

interventions without a home component achieved significant reductions in BMI, whereas those with a home component did not.

***/// All five meta-analyses that compared studies with or without parental involvement found better results in BMI and blood pressure among the studies with parental involvement. Parental involvement was identified as a moderating factor leading to greater success in three of these meta-analyses ///***

Three of the abovementioned meta-analyses found a greater beneficial influence on BMI or other weight-related outcomes due to a higher level of parental involvement. In the meta-analyses by Niemeier, Hektner and Enger (87) and Vasques et al. (50) described above, there were significant differences between levels of parental involvement with higher levels of involvement showing a greater effect on BMI reduction. In the meta-analysis by Krishnaswami et al. (90) also described above, the authors noted that the two studies with the highest community engagement performance scores achieved the highest outcome performance.

Lastly, in their 2013 meta-analysis described under essential criterion 1.1 of 21 combined diet and physical activity programmes among children aged 4–11 years in primary schools and their effect on BMI and other anthropometric measures, Williams et al. (67) found that the combined

diet and physical activity interventions with stakeholder involvement and family engagement were particularly effective, but they were unable to pool results for this aspect in particular due to heterogeneity of studies.

In addition to these meta-analyses, 18 reviews analysed parental involvement in school-based nutrition programmes. Six of these reviews only included studies that included parental involvement (70, 94-98), whereas 12 reviews compared studies with or without such involvement or investigating parental involvement as a feature of successful programmes (74, 78-80, 83, 99-105). Four reviews had analysis of parental involvement in school-based nutrition programmes as a main objective (94-96, 98), and four reviews examined the effect of different levels of parental involvement (94, 96, 99, 102). Only one of the reviews focused specifically on low- or middle-income countries and/or disadvantaged populations (70).

Among the six reviews only including studies of interventions with a parental involvement (70, 94-98), the four reviews where study of parental involvement was a main objective noted beneficial effect on BMI, dietary and other outcomes (94-96, 98). Hingle et al. in 2010 (94) systematically reviewed the effect of parental involvement in 24 obesity and NCD prevention studies, 16 of which were conducted in the school setting, comparing dietary interventions for children with and without a parental involvement component. Although limited conclusions could be drawn from this review because there were not enough studies making such comparisons, the authors observed that a greater proportion (100%) of studies using direct methods (e.g. parent attendance of educational or counselling sessions) achieved at least some dietary change (positive or mixed), while only 64% of studies using indirect methods (e.g. newsletters, tip sheets, invitations to attend events) achieved any changes in dietary outcomes. In 2018, Verjans-Janssen et al. (95) reviewed 25 school-based nutrition and physical activity intervention studies

with a direct parental involvement component (e.g. requesting that parents attend education sessions, asking parents to attend or participate in family behaviour counselling or parent training sessions) in primary school children. They found favourable results in 11 of 18 studies measuring BMI or BMI z-score, though most studies had small effect sizes. Results on nutrition behaviour were inconclusive, with five out of 11 studies reporting favourable results for all outcomes measured (e.g. SSB intake, fruit and vegetable intake, added sugar intake, red meat consumption). In a 2016 systematic review of 11 studies of participatory, school- and community-based NCD prevention interventions, Jourdan et al. (98) found positive effects at the organizational level (e.g. development of policies) and in healthier eating among adult stakeholders and children. The authors concluded that involvement of children and parents or communities has potential benefits; however, the number of relevant studies was small and there were methodological challenges. As part of the 2012 series of systematic reviews on various aspects of nutrition education in countries with a high or very high human development index mentioned in essential criterion 1.1, the USDA (96) conducted another systematic review of 10 RCTs



of parental involvement in nutrition education, of which seven were school-based. The authors concluded that limited and inconsistent evidence was available to assess the effects of parental involvement in nutrition education on children's dietary behaviour. Six of the 10 studies found an added benefit from parental involvement in at least one subgroup, of which three studies found this effect in girls but not in boys. One of two studies measuring the effect of increasing levels of parental involvement found a significant dose-response relationship. Studies conducted outside of the United States were more often effective.

Positive intervention effects in terms of reducing BMI, enhancing physical activity and improving fruit and vegetable consumption were also found in a 2015 systematic review by Langford et al. (97) of 26 diet and physical activity studies following the Health Promoting School approach, and therefore including a parent component. However, involving families — despite being an essential part of the Health Promoting School approach — was reported as highly challenging due to factors such as language barriers, misunderstanding the purpose of the programme and lack of time or opportunity. In the 2019 scoping review of 15 preschool multicomponent interventions in low socioeconomic settings in high-income countries described under essential criterion 1.1, Luybli, Schmillen and Sotos-Prieto (70) found that the nine successful studies, as well as the six inconclusive studies, included a parental involvement component. The authors noted that parental involvement is important in this age group, and such multicomponent interventions can address obesity in low socioeconomic settings.

Among the 12 reviews analysing the effect of parental involvement as a feature of successful programmes eight reviews (74, 79, 80, 99-103) pointed to family or community involvement as a factor leading to positive outcomes in terms of weight-related outcomes, fruit and vegetable consumption

or NCD risk factors, whereas four reviews found either no or mixed results (78, 83, 104, 105). In the 2018 systematic review of 56 weight gain prevention and management studies in children 2-19 years in various settings described under essential criterion 1.1, Bleich et al. (80) found that all 17 of the 24 school-based RCTs that reported positive results in weight-related outcomes used combined diet and physical activity interventions and included a secondary home setting.

Among younger children, a 2012 review of 12 obesity prevention studies among children aged 4-6 years old in the school or preschool setting by Nixon et al. (99), found that all four studies reporting improved weight outcomes had high or moderate parental involvement. The authors noted children's (and parents') perceived competence in making healthy changes in their diet and physical activity levels as a key element for success. In a 2017 systematic review of 43 preschool-based obesity prevention studies, Ward et al. (100) found that 13 of 18 studies including a dietary intake measure and 10 of 24 studies with an anthropometric measure demonstrated at least one successful intervention effect. They constructed an intervention strength based on approaches common in community health efforts for obesity (e.g. use of multiple strategies, policy or environment changes, frequent exposures or longer durations) and found this to be positively correlated with reporting of positive anthropometric outcomes for physical activity, diet and combined interventions. Furthermore, parent engagement components increased the strength of these relationships.

Among adolescents, the review described under essential criterion 1.1 by Meiklejohn, Ryan and Palermo (74) of 11 nutrition education studies in children aged 10-18 years, found that parental involvement (e.g. provision of newsletters, factsheets, meetings and shared homework tasks) was an additional component in all four studies with beneficial effect on BMI and in eight out of nine studies with beneficial effect on dietary intake.

In the 2006 review of 15 studies of fruit and vegetable promotion studies among primary and secondary school children described under essential criterion 1.1, Knai et al. (79) found that eight out of 11 studies including the active involvement of parents (at school and home) and three out of four studies including a community involvement component were associated with increased consumption of fruit and vegetables. Likewise, Silveira et al. (101) noted that parental involvement accentuated the positive effects on BMI, BMI z-score and fruit and vegetable consumption in a 2011 systematic review of 24 school-based studies among children aged 5–18 years focusing largely on nutrition education. In a 2018 systematic review of 41 school or preschool based nutrition education studies, Murimi et al. (102) found that 19 studies were successful in meeting their stated primary research objectives in terms of nutrition-related outcomes. Active parental involvement (e.g. face-to-face meetings, participation in nutrition or cooking classes, health fairs or tasting sessions) was associated with higher success than passive involvement (e.g. provision of messages, websites, homework) or no parental involvement, particularly in the preschool setting. In a broader systematic review of 37 school-based NCD risk factor prevention intervention studies, including healthy diets, Saraf et al. (103) in 2012 found that 80% of such interventions had positive effects on reducing NCD risk factors (e.g. nutrition knowledge, consumption of healthy foods, BMI, physical activity level) and that positive results were more likely when interventions included families and communities rather than schools alone.

On the other hand, four reviews included did not find improved effects as result of parental involvement. In a 2012 systematic review, Van Lippevelde et al. (104) investigated five studies on school-based obesity prevention programmes focusing on diet and/or physical activity to determine the effect of parental involvement on diverse outcomes (dietary knowledge, health behaviours,

BMI, BMI z-score, fat intake). While some positive effects of parental involvement were found, the evidence was inconclusive due to the lack of studies comparing interventions with and without a parent component. Likewise, Black, Matvienko-Sikar and Kearney (105) in 2017 found insufficient evidence to determine the impact of parental involvement in school and preschool interventions to improve dietary outcomes. In their review of 39 studies, of which 31 were conducted in schools or in preschools, substantial and statistically significant effects on dietary intake (fruit and vegetable or fat intake) were found in only one third of outcomes assessed, with no clear pattern appearing between the groups with and without a parent component. In the 2006 systematic review of 25 largely school-based obesity prevention studies focusing on diet and/or physical activity described under essential criterion 1.1, Doak et al. (83) found that slightly (but insignificantly) more of the non-effective interventions actively involved parents (57% vs. 47%) or the broader community (14% vs. 6%). In the systematic review of 14 school-based fruit and vegetable promotion studies also described in essential criterion 1.1, Aloia et al. (78) did not find positive associations between family or parental involvement and increases in fruit and vegetable consumption.

Four systematic reviews examined the effect of different levels of parental involvement, all of which are described above. Hingle et al. (94) and Murimi et al. (102) both found active methods (e.g. parent attendance of educational or counselling sessions, face-to-face meetings, participation in nutrition or cooking classes, health fairs or tasting sessions) to be more effective than passive methods (e.g. newsletters, tip sheets, invitations to attend events, provision of messages, websites, homework). USDA (96) found a significant dose-response relationship in one of two nutrition education studies measuring parental involvement. In children aged 4–6 years old, Nixon et al. (99) found that all four studies reporting improved weight outcomes had high or moderate parental involvement.

### *Essential Criterion 2.3: School staff training in nutrition and health-related issues*

School staff play a critical role in the implementation of many school-based health promotion interventions. While none of the systematic reviews in this report specifically assessed the effectiveness of school staff training in nutrition and health-related issues, several reviews of school-based nutrition interventions delivered by teachers mention the importance of adequate staff training and many of the primary studies included teacher training conducted alongside other activities. However, these aspects were seldom analysed to evaluate the impact of staff training apart from narrative descriptions from findings of individual studies.

Five systematic reviews were identified that examined aspects of school staff training or identified it as a success factor (79, 97, 102, 106, 107). Two Cochrane reviews by Wolfenden et al. (106, 107) in 2016 and 2017 systematically reviewed the effectiveness of strategies to improve implementation by regular staff of health promoting programmes including healthy diet and physical activity from 27 studies in schools and 10 studies in child care centres (e.g. preschools). Such strategies included staff education and training, performance feedback, prompts and reminders or implementation resources. While many studies reported significant improvements as a result of the implementation strategy compared to usual practice, the authors found insufficient evidence to draw conclusions regarding their effectiveness at improving implementation or improving staff knowledge, attitudes and skills.

The three other systematic reviews looked at teachers' training when assessing study designs or components of those studies that had shown effect, and identified training of teachers as an enabling factor. In the 2015 review of 26 school-based diet and physical activity programmes aligning with the Health Promoting School approach described previously under essential criterion 2.2, Langford et

al. (97) identified working with teachers to develop programmes and increase ownership and providing ongoing training, support and communication as moderators of positive results in terms of reducing BMI, enhancing physical activity and improving fruit and vegetable consumption. Furthermore, in the systematic review by Knai et al. (79) of 15 fruit and vegetable promotion interventions described under essential criteria 1.1 and 2.2, eight out of 11 studies using teacher involvement (e.g. training) as an intervention component had significant positive results on fruit and vegetable consumption. The authors observed that special training of teachers appeared to be associated with successful results in increasing fruit and vegetable intake. Finally, in the 2018 systematic review of 41 school or preschool based nutrition education studies described under essential criterion 2.2 above, Murimi et al. (102) found that studies that trained existing teachers or engaged nutrition and physical activity experts in the implementation were more likely to succeed.

### ***NFSI Component 3: Developing a nutrition and health promoting curriculum***

The third component of the NFSI framework concerns the school curriculum, which can be particularly important for nutrition. The essential criteria in this component relate to the development and implementation of curricula that include nutrition education, physical education and life-skills education, as well as to the regular monitoring and evaluation of these aspects of the curricula.

Most of the reviews identified concerned different aspects of nutrition education in schools. The number of reviews related to physical education was lower since this review of reviews only considered physical education activities that were implemented in combination with nutrition programmes. Likewise, few reviews were identified for nutrition-related life-skills education. No reviews were identified for monitoring and evaluation of school curricula.

### NFSI Component 3: Developing a nutrition and health promoting curriculum

- Ten meta-analyses and 28 reviews were identified relevant to essential criterion 3.1 that examined various aspects of nutrition education in schools, including one systematic review of studies from low- and middle-income countries.
- Eight of the 10 meta-analyses found significant improvements in weight-related or dietary outcomes.
- Four systematic reviews highlighted the benefits of integrating nutrition education into the formal curriculum, while one meta-analysis found that curriculum-based approaches were only effective when implemented alongside other teaching strategies.
- Effective nutrition education programmes were often identified as those that are behaviourally-focused, of longer duration and intensity, facilitated by trained staff, integrated into the curricula and/or implemented in combination with other approaches (e.g. changes to the environment, parental involvement).
- Effective approaches included enhanced curriculum, cross-curricular approaches, experiential and hands-on learning strategies (e.g. cooking classes, school gardening), contingent reinforcement approaches and peer-led education programmes.
- Information and communication technology (ICT) may have potential to improve dietary habits among adolescents in some settings.
- Thirteen meta-analyses and four systematic reviews were identified relevant to essential criterion 3.2 comparing physical activity education alone or in combination with nutrition activities.
- Nine meta-analyses and two reviews found better effects on weight-related, dietary or other outcomes for combined programmes than for those that only targeted physical activity.
- Eight reviews were identified relevant to essential criterion 3.3 examining life-skills education in the context of nutrition.
- Effective intervention components were suggested to be experiential learning, such as cooking or gardening skills.
- Self-efficacy and children's perceived competence in making healthy changes to their diet and physical activity levels were found to be associated with better outcomes.

#### *Essential criterion 3.1: Culturally appropriate and effective nutrition education*

Nutrition education is a common strategy within programmes to improve nutrition and dietary behaviours, practices and habits. It aims to achieve sustained changes in behaviour and build food and nutrition capacities. No particular WHO guideline exists for nutrition education, in schools or

other settings, but such activities should be age-appropriate, context-specific and underpinned by guidance on healthy and safe diets (108-110). FAO has developed a comprehensive planning guide for establishing context-relevant and age-appropriate effective nutrition education in primary schools (20), and is currently developing a white paper and a series of tools to enhance the methodological quality,

impact and scope of food and nutrition education in low- and middle-income countries (111).

Ten meta-analyses (53, 60, 92, 112-118) and 28 reviews (45, 68, 69, 74, 75, 78, 79, 96, 101, 102, 119-136) were identified that assessed the impact or effective components of school-based nutrition education.

Of the 10 meta-analyses relevant to nutrition education, four focused explicitly on school-based nutrition education (92, 112-114), whereas six considered the effect of nutrition education amongst other approaches (53, 60, 115-118).

All the four meta-analyses that explicitly focused on school-based nutrition education showed significant improvements in BMI, other weight-related outcomes, biochemical measures, dietary outcomes and knowledge. One of these was a 2015 review by Dudley, Cotton and Peralta (92) of 49 school-based studies to promote healthy eating that also examined the effect of different teaching approaches and strategies. In their meta-analysis of data involving 20 234 children they found that most teaching strategies led to positive changes, but in the pooled results, fewer strategies had mean effect sizes  $M_d > 0.4$ , above the selected cut-off for positive effect in this review. Curriculum-based approaches were most popular but only had mean effect sizes  $M_d > 0.4$  in the meta-analyses when implemented alongside other teaching strategies. Enhanced curriculum approaches were effective at increasing knowledge ( $M_d = 0.75$ ) but not at reducing sugar intake from beverages with added sugar or fruit juices ( $M_d = 0.28$ ). Cross-curricular approaches were effective to improve fruit and vegetable consumption ( $M_d = 0.63$ ) as well as decreasing sugar intake from beverages with added sugar or fruit juices ( $M_d = 0.42$ ). Experiential learning strategies (e.g. school garden, cooking demonstrations) were associated with the largest pooled mean effect size for preference and increased nutritional knowledge outcomes ( $M_d = 1.35$ ), and were also effective for

food consumption/energy intake ( $M_d = 1.31$ ) and for fruit and vegetable consumption ( $M_d = 0.68$ ).

In a 2018 meta-analysis of 30 studies, Wang et al. (112) found that educational interventions on health as single or multicomponent interventions among 35 296 children had significant effect on a range of adiposity-related outcomes, including BMI ( $-0.15 \text{ kg/m}^2$ ; 95% CI:  $-0.24, -0.05$ ,  $P = 0.003$ ), BMI z-score ( $-0.03$ ; 95% CI:  $-0.05, -0.02$ ,  $P < 0.001$ ), waist circumference ( $-0.97$ ; 95% CI:  $-1.95, 0.00$ ,  $P = 0.050$ ), triceps skinfold ( $-1.39$ ; 95% CI:  $-2.41, -0.37$ ,  $P = 0.008$ ), SBP ( $-1.13$ ; 95% CI:  $-2.20, -0.07$ ,  $P = 0.037$ ), total cholesterol ( $-4.04$ ; 95% CI:  $-7.18, -0.90$ ,  $P = 0.012$ ), and triglycerides ( $-2.62$ ; 95% CI:  $4.33, -0.90$ ,  $P = 0.003$ ). However, educational interventions were found to have little or no significant impact on the waist-to-hip ratio, DBP or high- or low-density lipoprotein. In another meta-analysis of eight studies on nutrition education interventions among 8 722 children in primary and secondary school, Silveira et al. (113) found in 2013 that, while only two individual studies demonstrated significant reductions in BMI, the pooled results from the eight studies gave a significant effect on BMI ( $-0.33 \text{ kg/m}^2$ ; 95% CI:  $-0.55, -0.11$ ). The largest effect was observed among the four studies with a duration greater than one year ( $-0.48 \text{ kg/m}^2$ ; 95% CI:  $-0.76, -0.19$ ). In China, Kong, Liu and Tao (114) performed a systematic review and meta-analysis in 2016 of 17 studies on school-based nutrition education interventions for obesity prevention in primary schools in the country. They found significant impact of interventions on obesity prevalence among the 14 studies of higher methodological quality involving 17 277 children (OR: 0.73; 95% CI: 0.55, 0.98) and in two studies involving 6 029 children where the duration was longer than 2 years (OR: 0.49; 95% CI: 0.42, 0.58).

Four of the six meta-analyses that considered the effect of nutrition education combined with other approaches or components showed beneficial effect on dietary outcomes (60, 115-117), one only showed



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***Effective nutrition education programmes were often identified as those that are behaviourally focused, of longer duration and intensity, facilitated by trained staff, integrated into the curricula and/or implemented in combination with other approaches (e.g. changes to the environment, parental involvement)***



an impact when nutrition education was combined with physical education (53) and one had mixed results (118). In the 2007 meta-analysis of seven school-based studies described under essential criterion 1.1, Howerton et al. (60) found increased fruit and vegetable consumption in the intervention group compared to the control group (+0.45 servings; 95% CI: +0.33, +0.59). All studies included a classroom-based component with lessons or workshops, coupled with a variety of other components (e.g. family involvement, food service changes). In a 2018 meta-analysis of 30 studies aiming to increase vegetable intake in children aged 2-5 years of age, 24 of which were conducted in preschool or child care settings, Nekitsing et al. (115) found a small-to-moderate effect (Hedge's  $g = 0.40$ ) from pooling results of 30 studies and a slightly higher effect ( $g: 0.42$ ; 95% CI: 0.33, 0.51,  $P < 0.001$ ) from pooling results of all 44 intervention arms. In subgroup analyses of intervention strategies, the effect of educational strategies alone was lower ( $g: 0.30$ ; 95% CI: 0.15, 0.46). The studies using taste exposure had a significantly higher impact on intake ( $g: 0.79$ ; 95% CI: 0.53, 1.05) than educational ( $g: 0.30$ ; 95% CI: 0.15, 0.46) strategies alone. In another meta-analysis of various interventions to promote fruit and vegetable consumption in primary schools (e.g. curricula, environment, teacher/parental involvement, fruit and vegetable schemes), Delgado-Noguera et al. (116) found in 2011 that the use of computer-based nutrition education was the only intervention strategy found to be effective at increasing fruit and vegetable consumption. Pooled results of two such programmes involving 606 primary school children showed effectiveness in improving consumption of fruit and vegetables (SMD: 0.33; 95% CI: 0.16, 0.50). In a 2017 meta-analysis of interventions to reduce SSB consumption and obesity which included 10 964 children, Vargas-Garcia et al. (117) found that interventions significantly decreased consumption (-76 mL/day; 95% CI: -105, -46). The subgroup analysis of 15 school-based interventions

which primarily consisted of nutrition education also resulted in a significant decrease in SSB consumption (-28 mL/day; 95% CI: -42, -12).

On the other hand, in the 2012 meta-analysis of 23 school-based physical activity and nutrition education interventions of 17 693 children between 7 and 17 years described under essential criterion 1.1, Friedrich, Schuch and Wagner (53) found that neither physical activity nor nutrition education interventions in isolation showed a significant reduction in BMI, but that the reduction was significant for combined interventions (SMD: 0.37; 95% CI: 0.63, 0.12). Furthermore, in their 2018 meta-analysis of 16 studies, 12 of which were school-based, Abdel Rahman et al. (118) only found a modest effect of educational and behavioural interventions in reducing SSB intake from two of the school-based studies (MD: 26.53 mL/day; 95% CI: 53.72, 0.66;  $P = 0.06$ ) and found no effect on reduction of BMI z-scores.

In addition to these meta-analyses, 28 reviews investigated different aspects of nutrition education in schools (45, 68, 69, 74, 75, 78, 79, 96, 101, 102, 119-136). Among these, five reviews examined integration into formal curricula or education resources (69, 79, 101, 119, 120), five considered the benefits of nutrition education delivered as part of multicomponent interventions (74, 75, 96, 102, 121), six examined or noted the use of hands-on activities (e.g., gardening or cookery classes) in nutrition education (102, 121-125), six focused on the use of ICT technologies as platforms for school-based nutrition education activities (126-131), one focused on the type of educator (132), one focused on peer-led nutrition education (133) and six considered the effectiveness of nutrition education as one approach amongst several school-based health and nutrition interventions (45, 68, 78, 134-136). Only one systematic review focused on studies from low- and middle-income countries (69).

Of the five reviews that examined integration into formal curricula or education resources, four systematic reviews highlighted the benefits of integrating nutrition education into the formal curriculum (69, 79, 101, 119). In a 2017 systematic review of nine studies of nutrition education integrated into the school curriculum and delivered by trained teachers in elementary schools in the United States, Price et al. (119) found significant reductions in BMI in five out of nine studies. Interventions with a duration greater than 1 year showed more pronounced results, with positive impact on reducing overweight, obesity and BMI outcomes. In the 2011 systematic review of 24 school-based nutrition education programmes described under essential criterion 2.2, Silveira et al. (101) found evidence of positive effects on rates of overweight and obesity and on fruit and vegetable consumption from interventions that were greater than one year in duration, introduced into the regular activities of the school or the curriculum, included parental involvement and/or provided fruit and vegetables as part of the school food services. In the 2006 systematic review of 15 fruit and vegetable promotion interventions by Knai et al. (79) described under essential criteria 1.1, 2.2 and 2.3, six out of nine studies integrating fruit and vegetable knowledge or preparation into the curriculum as an intervention component had significant positive results on consumption. In the 2012 systematic review of 25 school-based diet and physical activity interventions in low- and middle-income countries described

under essential criterion 1.1, Verstraeten et al. (69) noted that effective interventions integrated educational activities into the school curriculum. None of the intervention studies using nutrition education alone had a significant effect on mean BMI, but two high-quality studies conducted using combined diet and physical activity interventions through integrated curriculum delivered by teachers and accompanied by nutrition education of parents each had large effect sizes. In a 2016 scoping review of studies of 32 nutrition education resources, Peralta, Dudley and Cotton (120) found that most nutrition education resources included curriculum-based aspects and were delivered in and outside classrooms, through online or web-based learning. However, the resources were less likely to embed cross-curricular, experiential learning approaches and contingent reinforcement activities.

Five systematic reviews with an explicit focus on nutrition education considered the benefits of this approach delivered as part of multicomponent interventions (74, 75, 96, 102, 121). In the 2018 systematic review of 41 school or preschool based nutrition education studies described under essential criteria 2.2 and 2.3, Murimi et al. (102) found that 19 studies were successful in meeting their stated primary research objectives in terms of nutrition-related outcomes (weight-related outcomes; biochemical markers such as HDL-C; dietary intake of calories and/or various macro- and micronutrients; dietary consumption or




preference of, for example, fruits and vegetables, whole grains or unhealthy beverages or snacks; dietary diversity; children's nutrition knowledge; and food availability in cafeterias), whereas 19 studies only partially met and three did not meet their stated objectives on nutrition-related outcomes. Successful interventions were more often multicomponent and multilevel, implemented for more than 6 months with frequent exposures, engaged parents actively, trained existing teachers or engaged nutrition and physical activity experts in the implementation. The authors identified as a key factor of effectiveness the targeting of specific behaviours and making nutrition education behaviour-focused through age-appropriate and/or experiential activities. In the 2016 systematic review of 11 RCT studies of nutrition education implemented as part of multicomponent strategies for children 10–18 years described in essential criterion 1.1, Meiklejohn, Ryan and Palermo (74) reported that nine studies demonstrated significant changes in dietary intake (e.g. reduced consumption of SSBs, increased consumption of fruit and vegetables) and four studies obtained significant changes in anthropometric measures (e.g. BMI, weight change, percentage body fat). Other contributing factors were parental involvement, behaviourally-focused nutrition education and the use of theories to underpin the intervention design, incorporation of policy changes within

school settings (changes in canteens, food supply and vending machines) and combining nutrition education with physical activity programmes.

As mentioned under essential criteria 1.1 and 2.2, the USDA conducted a series of systematic reviews in 2012 on various aspects of nutrition education in countries with a high or very high human development index (75, 96, 121, 130, 132). In a systematic review of 14 studies, 10 of which were school-based, USDA (121) noted that six studies found multicomponent interventions to be more effective than single component interventions for at least one dietary outcome, three studies found single component nutrition education interventions to be more effective than multicomponent interventions for at least one dietary outcome, and eight did not find any difference between them. However, in another systematic review in the same series of 10 school-based nutrition education studies, USDA (75) found consistent evidence that combining nutrition education with changes to the school food environment is more effective for improving children's and adolescents' dietary intake than either component alone. Furthermore, in the same series USDA (96) found limited and inconsistent evidence from 10 studies that combining multiple approaches by involving parents in nutrition education improves dietary behaviour, though more positive effects were found among girls and in studies conducted outside the United States.





Six reviews examined or noted the use of hands-on activities, such as gardening or cookery classes, in nutrition education (102, 121-125). In the systematic review of 41 school- or preschool-based nutrition education studies described above, Murimi et al. (102) found that successful interventions included age-appropriate and/or experiential activities (e.g. hands-on learning, cooking or tasting session, play and games on topics that are important to the age group). Also described above, the systematic review of 14 multiple vs. single component nutrition education studies by USDA (121) noted that the three studies that consistently found better effect of multicomponent interventions were also the only ones to combine nutrition education with a hands-on component (e.g. cooking or gardening). In a 2019 systematic literature review of 44 school-based studies, Bailey, Drummond and Ward (122) found that nutrition education interventions to promote food literacy in adolescents improved dietary intake in eight out of nine studies, but the effect on long-term healthy dietary behaviour was mixed. Teaching of hands-on cooking skills and use of chefs or school gardens were identified as beneficial components. Four of five studies on school-based gardening showed a positive impact on fruit and vegetable consumption. All four studies that utilised experimental cooking and nutrition education programmes led by chef instructors showed positive results in overall cooking confidence, cooking skills and tasting new foods. The qualitative studies found that while adolescents value food literacy lessons and home economics teachers rate various aspects of food literacy as important skills, the school food environments are seldom comprehensively supportive of food literacy. In a 2009 systematic review of 11 studies on garden-based nutrition education programmes — eight of which were school-based — Robinson-O'Brien, Story and Heim (123) found that these programmes have the potential to promote fruit and vegetable

intake among youth and to increase willingness to taste fruits and vegetables among younger children. Among studies in the school setting, improvements were reported as result of exposure to garden-based nutrition education in two out of three studies measuring fruit and vegetable intake, two out of five studies measuring willingness to try vegetables, three out of three studies reporting on willingness to taste vegetables and three out of five measuring nutrition knowledge. In a 2015 systematic review of 102 quantitative and qualitative studies of school architecture and design, Frerichs et al. (124) analysed 21 studies of school garden on-site food production. They found that these could easily be integrated into curricula and have benefits beyond improved dietary behaviour, however, barriers such as intensive time and resource requirements were identified. They also analysed 14 studies relating to school teaching kitchens and found that these were popular among staff and students and could easily be integrated with other academic topics. Five of seven studies measuring dietary outcomes found significant increases in the consumption of, for example, vegetables. In a narrative review of six school-based hands-on culinary skill interventions — often combined with components such as nutrition education, gardening, tasting sessions or trips to farmers' markets — Muzaffar, Metcalfe and Fiese (125) in 2018 identified too few studies to draw conclusive findings. However, all six studies were successful in meeting their objectives and the authors noted quantitatively significant effects on food preferences, cooking skills, cooking self-efficacy, cooking behavioural intentions, food-preparation frequency, knowledge, healthy dietary intake, BMI and blood pressure from three of the studies. Furthermore, qualitative evaluations available from all six studies indicated substantial effects in terms of programme appeal and improvements in cooking skills and healthy eating.



Mr. Eagles Kids Childhood Obesity Project


Another six reviews focused on the use of ICT technologies as platforms for school-based nutrition education activities and these generally showed positive results, at least in the short term (126-131). In 2014, Ajie and Chapman-Novakofski (126) reviewed 15 studies on computer-based nutrition education interventions targeting overweight and obesity in adolescents 12–18 years, 10 of which took place in the school setting. Most of these 10 studies found significant results in at least one of the dietary or anthropometric outcome measures post-intervention, albeit some were

only successful among at-risk subgroups or among girls. Likewise, Whittemore et al. (127) in 2013 reviewed 12 school-based internet obesity prevention programmes among adolescents and found that 10 of these improved dietary behaviour or physical activity in the short term. However, only one out of four studies that examined the effect on BMI showed a significant decrease. Two of the three studies that compared web-based nutrition education to traditional nutrition education noted a greater effect on health behaviours and BMI for the web-based education interventions. Hamel and Robbins (128) conducted a 2013

systematic review of 15 computer- and web-based interventions to promote healthy eating among children and adolescents, 10 of which were conducted in the school setting. Although 11 of the 15 interventions included in the review resulted in statistically significant positive changes in weight- or diet-related outcomes, these changes were not maintained in studies that included post-intervention follow-up. Interventions conducted in schools or using individually tailored feedback enhanced success. The authors suggest that the closely supervised environment of a classroom setting, along with the potential for social support from teachers or fellow classmates, may enhance the effect of a school-based intervention over a home-based approach that may be completed alone. In another systematic review of 11 school-based interventions using ICT including computer games, programmes, text messages and interactive CD-ROMs, do Amaral e Melo et al. (129) found in 2017 statistically significant positive effects on diet in five of the studies. The authors were unable to determine the most effective type of intervention due to the heterogeneity of studies. However, they suggest that long-term interventions aimed at changing a single health

behaviour (e.g. fruit and vegetable intake) and with frequent exposure may improve nutrition behaviours. Furthermore, interventions that target diet and physical activity together seem to have greater impact, as well as interventions using games. As part of the series of systematic reviews on various aspects of nutrition education in countries with a high or very high human development index described above, the USDA (130) conducted a systematic review of 24 studies on nutrition education delivered via digital media and/or technology, 15 of which were school-based. They found moderate evidence that that nutrition education delivered via digital media/technology (computer- and internet-based programmes) may be effective for improving dietary intake-related behaviours among children and adolescents: 21 of 24 studies found significant effect on dietary intake-related behaviours in at least one population subgroup, and in 15 of these the intervention was more effective than the control (no intervention or other delivery method). In a 2019 systematic review of 29 various school-based healthy eating intervention studies in adolescents, Calvert, Dempsey and Povey (131) found that, overall, 24 of the studies were successful in





promoting dietary behaviour change. Among the interventions that appeared to be more effective, were those that used educational media to deliver health messages (all seven studies with this component were successful) and incorporated computer-based individualized feedback with normative information on eating behaviours (four of five studies with this component were successful).

One systematic review by the USDA (132) in the series of systematic reviews in 2012 on various aspects of nutrition education mentioned above focused on the type of educator. However, not more than one study was considered eligible for inclusion, thus there was insufficient evidence to draw conclusions. Moreover, the results from this study were mixed, resulting for the most part in no significant differences in dietary intake between the intervention groups, although the changes in dietary intake were significantly greater in the teacher group compared to the nutritionist group.

Another review focused on peer-led nutrition education. In this 2016 systematic review of 17 school-based, peer-led nutrition education interventions, Yip et al. (133) found such approaches to be effective in improving knowledge, self-efficacy and attitudes towards healthy eating. Such programmes also generated favourable outcomes for anthropometric measures (BMI, waist circumference) or other biological measures (blood pressure) in all four studies measuring these outcomes. Furthermore, a dose-impact relationship was observed for varying levels of participation in all three studies investigating this aspect.

Among the six reviews that considered nutrition education as one approach amongst several school-based school health and nutrition interventions, six reviews found positive results on various weight-related and dietary intake indicators, but generally concluded that it is most effective

when delivered as part of a more comprehensive package (45, 78, 134), whereas three reviews found moderate or inconclusive evidence (68, 135, 136). In the 2016 systematic review of 14 interventions targeting fruit and vegetable consumption among children in pre- and primary schools in the United States described under essential criteria 1.1 and 2.2, Aloia et al. (78) found that eight of the studies showed significant increases in consumption of fruit and vegetables among pre- and primary school-aged children. The authors identified nutrition education as one of the most promising components, although further research would be needed to strengthen the evidence. In the 2017 systematic review of 36 school-based and largely educational interventions to reduce SSB consumption among adolescents aged 12–17 years described under essential criterion 1.1, Vézina-Im et al. (45) found that although the 10 legislative/environmental studies (e.g. ban on sugary drinks in schools) had the highest success rate (90%), the 20 educational/behavioural interventions (e.g. nutrition education) and the six interventions that were both educational/behavioural and legislative/environmental were also successful (65% and 66.7%, respectively). In a 2015 systematic review of eight RCT studies to reduce SSB consumption, seven of which were school-based, Avery, Bostock and McCullough (134) found that four of six studies focusing on educational approaches reduced the risk of being overweight, though one of these also provided a replacement drink. The authors concluded that school-based education programmes to reduce SSB consumption, and which include follow-up modules, offer opportunities for implementing effective, sustainable interventions.

On the other hand, three of the eight reviews comparing nutrition education to other approaches did not find positive results. In the 2011 systematic review of 11 school-based obesity prevention interventions described under essential criterion

1.1, De Bourdeaudhuij et al. (68) found that interventions focusing on education alone have less of an effect on obesity prevention than multicomponent programmes where education is combined with environmental modifications. In a 2010 review of programmes targeting healthy diets in primary and secondary schools in Europe, Van Cauwenberghe et al. (135) found moderate evidence that educational interventions (i.e. a nutrition education curriculum that was delivered by the teachers) can improve dietary behaviour in adolescents and limited evidence that it can improve dietary behaviour in children, while evidence of the effect on body composition was inconclusive. For both children and adolescents, combined educational and environmental interventions were more effective than those targeting education alone. Likewise, in a 2018 systematic review of 48 school cafeteria environment studies, Gordon, Dynan and Siegel (136) found that nutrition education interventions ("system 1" type of interventions) were less effective than environmental interventions ("system 2" type of interventions) within the school cafeteria to impact nutrition-related outcomes (e.g. BMI, consumption and/or selection of fruits, vegetables, sugary drinks, plain milk and/or whole grains) (four of eight system 1 studies vs. 24 of 27 system 2 studies,  $P = 0.033$ ). The review is further described under essential criterion 4.1.

*Essential criterion 3.2: Age-, sex- and culturally-appropriate physical education curriculum*

WHO guidelines recommend that children and youth aged 5–17 should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily, but longer durations would provide additional health benefits (137). WHO guidelines also exist for preschool age children, which, among other things, recommend that children between 3 and 4 years should spend at least 180 minutes in a variety of types of physical

activity at any intensity per day, and that at least 60 minutes of those should be on moderate- to vigorous intensity physical activity (138). For children and young people, physical activity includes play, games, sports, transportation, chores, recreation, physical education or planned exercise and can be done in the context of the school. Both the 2004 WHO *Global Strategy on Diet, Physical Activity and Health* (139) and the 2018 WHO *Global Action Plan on Physical Activity* (140) call for physical education and enabling environments for physical activity in schools.

A wealth of reviews exists on the effect of promoting physical activity in schools. However, to limit the scope of the evidence base for this review of reviews for the NFSI framework, only those reviews that assessed the effectiveness of combined physical activity and nutrition versus physical activity alone were considered. This resulted in 13 meta-analyses (46-50, 53-58, 61, 62) and four reviews (69, 81, 83, 85).

As described under essential criterion 1.1, five of the 13 meta-analyses comparing physical activity education alone or in combination with nutrition activities found significant improvements of the combined programmes on weight-related outcomes (48, 50, 53, 54) or blood pressure (61). These improvements, however, were not found for programmes that focused on physical activity alone.

Another four meta-analyses described under essential criterion 1.1 found significant effect of both combined diet and physical activity programmes and those focusing on physical activity alone on weight-related outcomes (47, 49, 55) or blood lipids (62), though the pooled effect sizes were larger for the combined programmes. In the 2011 Cochrane review of 55 long- and short-term childhood obesity prevention programme studies, 43 of which included an educational setting, Waters et al. (47) found the greatest overall effect on BMI or BMI z-score





from combined physical activity and dietary interventions (SMD: -0.18; 95% CI: -0.27,-0.09), and a slightly smaller effect size from physical activity interventions alone (SMD: - 0.11; 95% CI: -0.19, -0.02). In 2017, updating the review by Waters et al. (47), Gori et al. (49) reviewed 72 studies in overweight or obese primary school age children, 47 of which were school-based, and found significant results for combined diet and physical activity interventions in children aged 6–12 years (mean BMI-SDS: -0.13; 95% CI: -0.19, -0.06) with a smaller effect size in the same age group for physical activity alone (mean BMI-SDS: -0.11; 95% CI: -0.16, -0.06). In the 2012 meta-analysis of 43 studies on school-based interventions, Lavelle, Mackay and Pell (55) found significant reduction in BMI from combined diet and physical activity interventions (-0.17 kg/m<sup>2</sup>; 95% CI: -0.29 to -0.06,  $P < 0.001$ ) and a smaller effect from the physical activity interventions used in isolation (-0.13 kg/m<sup>2</sup>;

95% CI: -0.22 to -0.04,  $P = 0.001$ ). In the 2014 meta-analysis of 17 child obesity prevention studies focusing on blood lipids, Cai et al. (62), found significant improvements in LDL-C from combined programmes (WMD: -8.49 mg/dL; 95% CI: -12.77, -4.21) which was larger than from programmes focusing on physical activity alone (WMD: 2.67mg/dL; 95% CI: -4.30, -1.03).

Furthermore, two other meta-analyses described under essential criterion 1.1 had mixed results when comparing physical activity alone or in combination with diet (56, 57). In the 2019 Cochrane systematic review and meta-analysis of 153 obesity prevention studies, of which 91 were school-based and 22 were in kindergartens or preschools, Brown et al. (57) found an effect of combined diet and physical activity interventions in children aged 6–12 years on BMI z-score (-0.04; 95% CI: 0.08, -0.01) and on BMI from physical

activity alone (-0.10 kg/m<sup>2</sup>; 95% CI: -0.14, -0.06). In adolescents between 13 and 18 years, significant effect was found of physical activity alone on BMI z-score (-0.20; 95% CI: -0.30, -0.10) and on BMI (-1.53 kg/m<sup>2</sup>; 95% CI: -2.67, -0.39), with no effect from the combined interventions. In China, Feng et al. (56) reviewed 76 school-based obesity intervention studies in 2017 and found that combined diet and physical activity interventions with health education had a significant effect and slightly larger effect on BMI than physical activity only interventions in treatment studies ((SMD: -1.80; 95% CI: -2.15, -1.44) vs. (SMD: -0.91; 95% CI: 1.15, 0.67)) whereas in prevention studies only the combined approach was effective (SMD: 0.19; 95% CI: -0.27, -0.11).

In contrast, one meta-analysis found better effect of interventions employing physical activity alone than of programmes combining diet and physical activity. In this 2014 meta-analysis, Langford et al. (46) did find an effect of multicomponent interventions employing multiple approaches (i.e. educational, environmental and family involvement) aligned with the Health Promoting School approach. Examining programme components however, they found no effect of the combined diet and physical activity interventions but significant effect on BMI (MD: -0.38 kg/m<sup>2</sup>; 95% CI: 0.73, 0.03) and BMI z-score (MD: -0.47; 95% CI: -0.69, -0.25) of interventions focusing on physical activity alone.

Finally, in the 2013 comparative effectiveness review and meta-analysis of 124 school-based interventions in the United States, Wang et al. (58) found strong evidence for school-based combined diet and physical activity interventions with a home component, whereas moderate strength of evidence was found for diet or physical activity interventions alone. However, results were only pooled for the combined diet and physical activity interventions, but not for interventions that addressed either one alone.

In addition to these meta-analyses, findings from two of the four reviews included under essential criterion 1.1 support the usefulness of integrating physical activity within nutrition programmes for better effect (69) as well as for long-term results (81). In the 2009 systematic review of 34 “lifestyle” intervention studies to prevent obesity among schoolchildren, Brown and Summerbell (81) found that the efficacy of interventions targeting physical activity alone was inconsistent, whereas combined interventions which targeted both diet and physical activity may help prevent children from becoming overweight in the long term. In low- and middle-income countries, Verstraeten et al. (69) conducted in 2012 a systematic review of 15 studies targeting physical activity and dietary behaviours for the primary prevention of obesity in children and adolescents aged 6–18 years. While four out of the five physical activity intervention studies had positive effect, the largest effect size on BMI came from two high-quality studies of combined diet and physical activity interventions.

In contrast, two other systematic reviews did not find the combined physical activity and nutrition programmes more effective than physical activity programmes alone (83, 85). In the 2006 systematic review of 25 largely school-based obesity prevention studies focusing on diet and/or physical activity, Doak et al. (83) found that slightly (but insignificantly) more of the non-effective interventions intervened on both diet and activity (88% vs. 82%). Similarly, in the 2008 systematic review of 14 school-based obesity prevention programmes of at least 6 months duration, Kropski, Keckley and Jensen (85) did not find that combined diet and physical activity interventions were more effective than interventions with either component alone. Significant reduction in overweight was reported in at least one subgroup in five of 11 combined studies and one of two physical activity studies.

### *Essential criterion 3.3: Healthy living and life-skills education curriculum*

In addition to nutrition education and physical education, healthy living and life-skills education should be included in the curriculum of nutrition-friendly schools. WHO defines life skills as “abilities for adaptive and positive behaviour that enable individuals to deal effectively with the demands and challenges of everyday life” (WHO, 2003). These skills include the psychosocial competencies and interpersonal skills necessary for decision-making, problem solving, communication, critical thinking and self-management, as well as, for example, critical evaluation of nutrition advertisements or countering social pressure to adopt unhealthy eating habits. In this way, life-skills education enables children and adolescents to manage a healthy lifestyle, including nutrition.

Eight reviews were identified that analysed life-skills education related to nutrition (98, 99, 122, 123, 125, 127, 133, 141). Three reviews attributed programme success or effectiveness to the development of life skills (99, 122, 141). In the 2012 systematic review of strategies to prevent overweight and obesity in children aged 4–6 years described under essential criterion 2.2, Nixon et al. (99) noted that children’s self-perceived competence in making healthy changes in their diet and physical activity levels was a key element for success. Furthermore, interventions with the highest success included development of skills, behavioural capability and self-efficacy, in addition to parental involvement. A 2014 systematic review by Hersch et al. (141) examined evidence from eight studies — seven of which were school-based — measuring the impact of cooking programmes on food preparation skills, dietary intake, cooking confidence, fruit and vegetable preferences, attitudes toward food and cooking- or food-related knowledge. Findings suggested that cooking programmes may have a positive impact on children’s food-related preferences, attitudes

and behaviours. Similarly, as described under essential criterion 3.1 earlier, the 2019 systematic literature review by Bailey, Drummond and Ward (122) of 44 school-based food literacy studies noted that four out of five studies on school-based gardening showed a positive impact on fruit and vegetable consumption. Furthermore, all four studies utilising experimental cooking and nutritional education programmes led by chef instructors showed positive results in overall cooking confidence, cooking skills and tasting new foods. As highlighted above, the authors noted from qualitative studies that both adolescents and home economics teachers value food literacy skills, but that school food environments are seldom supportive.

Five reviews reported on self-efficacy of students as an intervention outcome (98, 123, 125, 127, 133). In the 2016 systematic review by Yip et al. (133) of 17 peer-led nutrition education programmes described under essential criterion 3.1 above, 13 studies that evaluated self-efficacy, knowledge, intentions and attitudes related to health behaviours showed improvement and two studies that measured self-esteem also reported improvements. One study that reported on body image found improvement in both the intervention and control groups. Despite the potential of peer-led programmes to improve knowledge, self-efficacy and attitudes towards healthy eating, the authors highlight the need for more research to determine the impact of these changes on diet quality and for more studies to use validated tools to measure attitudes and self-efficacy so as to strengthen the quality of evidence. In the 2013 review of 12 school-based Internet obesity prevention programmes also described under essential criterion 3.1 above, Whittemore et al. (127) found improved adolescents’ self-efficacy for healthy eating and physical activity in all three studies that targeted self-efficacy. An additional study included training in coping skills as a part of

the interactive Internet programme, but there was no difference in outcome measures between the Internet education and behavioural programme with or without the addition of coping skills training.

In the 2009 review of 11 garden-based nutrition education studies also described under essential criterion 3.1 above, Robinson O'Brien, Story and Heim (123) included two studies that measured self-efficacy to consume fruit and vegetables. They noted that self-efficacy increased in the intervention group in one study, but it did not improve in either the intervention or control group in the other study. In the 2016 systematic review of the involvement of young people in school- and community-based NCD prevention interventions described under essential criteria 1.1 and 2.2, Jourdan et al. (98) found that the main objective of some interventions was to empower children and increase their leadership and advocacy skills for health. The active involvement of children as stakeholders in these school-based interventions led to outcomes related to self-efficacy and leadership skills that support healthy

behaviours. Likewise, in the narrative review of six school-based hands-on culinary skill interventions also described under essential criterion 3.1 above, Muzaffar, Metcalfe and Fiese (125) noted in 2018 significant effects on outcomes such as cooking skills, cooking self-efficacy, cooking behavioural intentions, food-preparation frequency and knowledge in three studies reporting quantitative results. They also noted substantial effects reported qualitatively from all the six studies on, for example, cooking skills.

#### ***NFSI Component 4: Creating a supportive environment***

The essential criteria included under component 4 are intended to create a school environment that is supportive of a healthy diet. These include healthy foods and beverages through school meals, food vendors and snack bars, as well as adequate facilities to prepare and eat those foods, positive messaging and absence of marketing of unhealthy foods, water and sanitation facilities, space for physical activities and a supportive environment which has positive role models and is free from bullying.

Most of the evidence identified concerned the availability of foods and beverages in schools. Some evidence was identified for WASH, marketing of foods and beverages in schools and role-modelling of healthy behaviours. Few reviews were identified that looked at school-based nutrition programmes and positive messaging or adequate eating places or cooking facilities, while no reviews were identified that specifically focused on the impact on nutrition of clean and separate toilets for boys and girls, spaces for physical activity or action against bullying, stigmatization and discrimination.



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## NFSI Component 4: Creating a supportive environment

- Nine meta-analyses and 24 reviews were identified relevant to essential criterion 4.1 considering the promotion of healthy eating through meals and snacks available or provided in schools. Many of these reviewed current policies and standards implemented in countries. Three of the meta-analyses and five of the reviews were conducted in low- and middle-income countries or in disadvantaged populations.
- School meal standards, competitive food and beverage policies and school food procurement policies had beneficial effects on food and beverage availability, purchase or consumption and/or dietary intake, but the results were less conclusive about the effect on weight-related outcomes unless physical activity was simultaneously addressed.
- School feeding programmes in low-income or disadvantaged settings improved weight gain, micronutrient status and energy intake, while participation in school breakfast programmes in high-income countries helped prevention of obesity. In the same settings, provision of fortified foods or beverages through schools improved micronutrient status, particularly anaemia reduction, and in some cases anthropometric outcomes.
- Providing free or subsidized fruit and vegetables often increased consumption, including in one study after the scheme had finished.
- Two meta-analyses and seven systematic reviews were identified relevant to essential criterion 4.2 considering messaging, incentivising desired behaviour or use of labelling to encourage healthy eating in the school, which resulted in improvements in outcomes related to diet, food purchases and preferences, with mixed results for weight-related outcomes. Incentives should not lead to increased food waste.
- One review examined food and beverage marketing specifically in schools, relevant to essential criterion 4.3. Children are commonly exposed to marketing of unhealthy foods and beverages in and around schools through a variety of strategies, especially in high schools and areas with lower socioeconomic status. Restrictive policies or guidelines were not common and, where they did exist, were often breached.
- One systematic review which examined eating places and cooking facilities in schools relevant to essential criteria 4.4 and 4.5, identified overcrowding in the cafeteria or lack of appropriate kitchen facilities and equipment as barriers to healthy school environments for eating.
- Three systematic reviews were identified relevant to essential criterion 4.6, analysing aspects of access to safe drinking water relating to nutrition outcomes. They found positive effects on water consumption and mixed effects on SSB consumption and weight-related outcomes.
- One meta-analysis and one systematic review relevant to essential criterion 4.7 examined water, sanitation and hygiene (WASH) in the school setting relating to nutrition outcomes. Adequate hand washing and sanitation reduced risk of diarrhoea, amongst other outcomes.
- One meta-analysis and two systematic reviews discussed evidence for modelling healthy dietary behaviours relevant to essential criterion 4.11, focusing on improved intervention effectiveness to reduce the consumption of SSBs and other healthy eating behaviours. Modelling could be, for example, by parents, peers or teachers.

*Essential criterion 4.1: School meals, food vendors and snack bars (if present) promote healthy eating*

No specific guidelines or recommendations exist from WHO regarding the quality or composition of foods and beverages in schools. However, the general guidance related to healthy diets and nutrient intake also applies to the school setting and recommends the establishment of standards to foster healthy dietary practices through ensuring the availability of healthy, safe and affordable food in preschools, schools, other public institutions and in the workplace (110). Four of the five keys to a healthy diet apply to school-age children and should be encouraged in the school environment: 1) eat a variety of foods, 2) eat plenty of fruit and vegetables, 3) eat moderate amounts of fats and oils, and 4) eat less salt and sugars (108). Furthermore, school foods can also help students to reach dietary goals for nutrients such as sodium and potassium. The WHO guideline on sodium recommends a reduction in sodium intake to control blood pressure in children and the WHO guideline on potassium suggests increased potassium intake from food to control blood pressure in children (142, 143). In areas where anaemia is 20% or higher in school age children, WHO recommends point-of-use fortification of foods with iron-containing micronutrient powders in children aged 2–12 years (144). WHO also recommends fortification of staple foods such as wheat flour, maize flour and corn meal with iron to prevent iron deficiency in populations, particularly vulnerable groups such as children and women (145, 146).

The WHO School Policy Framework (147) notes that food served in schools should adhere to nutrition standards based on national or regional dietary guidelines. This document proposes that in countries where meals are provided at school, 30% of recommended nutrient intake for age is used as a reference value to plan the content of the meals served, which can also provide guidance for the provision of adequate serving sizes in school meals. The implementation plan for the

recommendations of the commission on ending childhood obesity (28) reiterates that settings such as schools should be required to create healthy food environments by setting standards for foods that can be provided or sold in schools.

Nine meta-analyses (36, 59, 67, 91, 115, 116, 148-150) and 24 reviews (35, 37-45, 76, 77, 79, 124, 131, 135, 136, 151-157) were identified relevant to promotion of healthy eating through school meals or snacks available or provided in schools. Among these, four meta-analyses (36, 67, 91, 115) and 17 reviews (35, 37-45, 79, 124, 131, 136, 151-153) considered the availability of healthy foods and beverages implemented through policy or other measures, whereas six meta-analyses (59, 67, 116, 148-150) and nine reviews (37, 44, 76, 77, 135, 154-157) considered the provision of foods, beverages or snacks such as fruits and vegetables in schools.

The four meta-analyses considering the availability of foods and beverages (36, 67, 91, 115) generally found beneficial effect on dietary outcomes, but less often on weight-related outcomes. In the 2018 systematic review and meta-analysis of 91 studies on different types of school food environment policies described under essential criterion 1.1, Micha et al. (36) found effects on various outcomes. From 29 studies of competitive food and beverage standards or policies (restricting, for example, SSBs, unhealthy snacks, foods or beverages high in calories or specific nutrients, and/or large portion sizes), positive effects were found on total consumption of SSBs (0.18 servings/day; 95% CI: -0.31, -0.05), total consumption of unhealthy snacks (-0.17 servings/day; 95% CI: -0.22, -0.13) and in-school consumption of unhealthy snacks (-0.05 servings/day; 95% CI: 0.08, -0.02), with no effect found on in-school SSB consumption, total calorie intake or overweight/obesity. From 39 studies of school meal standards (mainly for lunch meals), positive effects were found on fruit consumption (+0.76 servings/day; 95% CI: +0.37, +1.16), total fat intake



(1.49%E; 95% CI: -2.42, -0.57), saturated fat intake (-0.93%E; 95% CI: -1.15, -0.70), sodium intake (170 mg/day; 95% CI: -242, -98) and BMI percentile (-1.0; 95% CI: -1.62, -0.39). Positive effects were also seen on increased milk consumption and carbohydrate intake in these studies, but no effect was seen on intakes of total calories, dietary fibre or whole grains, or on other adiposity and metabolic measures. They also studied the effect of direct or indirect fruit and vegetable provision, which is described below.

In the 2018 meta-analysis of 30 studies aiming to increase vegetable intake in children 2-5 years of age described under essential criterion 3.1, 24 of which were conducted in preschool or child care settings, Nekitsing et al. (115) found a small-to-moderate effect (Hedge's  $g = 0.40$ ) from pooling results of 30 studies and a slightly higher effect ( $g: 0.42$ ; 95% CI: 0.33, 0.51,  $P < 0.001$ ) from pooling results of all 44 intervention arms. In subgroup

analyses of intervention strategies, the studies using taste exposure had a significantly higher impact on intake ( $g: 0.79$ ; 95% CI: 0.53, 1.05) than food service modifications alone ( $g: 0.30$ ; 95% CI: 0.10, 0.50).

In the 2019 systematic review and meta-analysis described under essential criterion 2.2, Nathan et al. (91) examined the effect of 10 school- or centre-based studies aiming to improve the quality of foods brought from home, e.g. lunch boxes. In addition to parental involvement, interventions included components such as physical resources (e.g. lunch packs, containers) and/or were linked to development of a policy and the communication of this policy to parents. A meta-analysis of four studies (two in schools and two in centres) found a moderate increase in vegetables brought from home (SMD: 0.40; 95% CI: 0.16, 0.64,  $P = 0.001$ ) but not fruit. Sub-analyses by setting revealed that a significant



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increase remained in centre-based studies, but not in school-based studies. Mixed results were reported for this and other nutrition-related outcomes (e.g. provision and/or consumption of fruit and vegetables, discretionary foods and/or SSBs). Two multicomponent studies, conducted in a centre and school respectively, reported effects on weight-related outcomes. In the 2013 meta-analysis by Williams et al. (67) on the effect of 21 school diet and physical activity studies described under essential criteria 1.1 and 2.2, five of the studies focused on diet-related policies aimed at increasing availability of healthy foods and beverages or decreasing availability of unhealthy foods and beverages within schools (e.g. removing low nutrient and/or energy-dense foods, fried potato products, desserts and whole or 2% milk from cafeterias, ensuring fruit and vegetables are available in the cafeteria, etc.). The pooled results of these five studies, however, gave a non-significant decrease in BMI z-score.

Among the 17 reviews that evaluated studies that addressed the availability of foods and beverages in or around schools, 10 reviews concerned school food and nutrition policies described under essential criterion 1.1 (35, 37-45), five reviews focused on other measures such as standards that may not have been implemented by policies (79, 124, 131, 151, 152) and two focused on softer measures such as nudging (136, 153).

The 10 school food and nutrition policy studies described under essential criterion 1.1 generally found positive effects on outcomes related to food and beverage availability in schools and diet-related outcomes, including intake, consumption or purchase, while results were mostly mixed regarding the effect on weight-related outcomes.

In the 2019 systematic review of 33 natural experiments on childhood obesity prevention and control, Bramante et al. (35) found that

school-based policies focusing on both the food and beverage and physical activity environments (versus targeting only one of those environments) consistently showed improvements in BMI. Furthermore, three of four school-based studies that focused on the food and beverage environment showed reduced SSB consumption. These three studies evaluated state- or school-wide policies to decrease access to SSBs. One of three school-based studies that focused on the food and beverage environment showed increased fruit and vegetable consumption, as result of implementing a policy on the sale of competitive foods and beverages.

In the 2014 systematic review of effects of 24 studies of state and district competitive food and beverage laws and policies, Chriqui, Pickel and Story

(41) found that 15 of the interventions had outcomes in the expected direction. Such positive results were found in two out of four studies measuring weight or BMI, in six out of 11 measuring consumption, purchase or dietary intake, and in 11 out of 13 measuring availability and access. In the 2018 systematic review of 26 studies on competitive foods and beverage in schools in the United States, Sildén (42) found that competitive foods and beverages are pervasive in schools, but evidence was lacking that such products cause overweight or obesity in children. On the other hand, the author noted that there was a positive association between competitive food and beverages policies and weight-related and/or dietary outcomes, and

***Providing free or subsidized fruit and vegetables often increased consumption, including in one study after the scheme had finished***





provided examples of several cases where caloric intake and/or overweight/obesity measures had improved. In the 2015 systematic review of 37 studies of policy and built environment changes, Mayne, Auchincloss and Michael (39) included five school-based nutrition policy studies concerning restrictions on sugary foods and beverages or higher fat foods, and/or increases in availability of milk or fruit/vegetables. Four of five studies measuring dietary outcomes (e.g. energy density, consumption of low-nutrient-density food or SSBs, and calorie, fat or fruit and vegetable intakes) reported results in the expected directions, whereas one had mixed results. The only study measuring weight-related outcomes reported mixed results. Similarly, in the 2014 systematic review of 18 studies of school food environment policies or interventions, Driessen et al. (38) found that all but one involved changes to the availability of foods in school canteens and produced clear, positive changes in diet or purchases. Fifteen out of 16 studies measuring purchasing behaviour or dietary outcomes reported a significant intervention effect. Two out of four studies measuring BMI found positive effects, however both studies were uncontrolled and therefore it is unknown whether changes in BMI resulted from the policy or some other environmental change. The authors suggested that high-level policy changes at district, state or national level can positively impact the school food environment and improve children's diets.

In the 2019 Cochrane review of 58 studies, von Philipsborn et al. (44) conducted a subanalysis on seven studies of school nutrition standards and found that reduced SSB availability within the school was associated with reduced intake in children in five of the studies, three of which involved a policy-level measure. The authors noted an indication that reduced availability of SSBs in schools may increase compensatory sugary drink consumption outside school among older students, but may not affect body dissatisfaction or dieting behaviour. They also noted that one study of improved placement of plain milk in school cafeterias did not affect the selection and consumption of sugar-sweetened or plain milk. In another subanalysis of healthier selections in vending machines in workplaces and schools, the one study in schools reported significant effect on SSB intake. Likewise, in the 2017 systematic review of 36 school-based SSB reduction interventions in adolescents described under essential criteria 1.1 and 3.1, Vézina-Im et al. (45) noted that the 10 studies involving legislative measures or structural changes to the environment (e.g. banning SSBs from school cafeterias or replacing them with healthier alternatives) were the most effective. Nine of 10 such studies resulted in decreased consumption of SSBs.

In the 2009 systematic review of 27 studies of school food and nutrition policies worldwide targeting the food environment (e.g. nutrition guidelines, regulation of food and beverage

availability, price intervention), Jaime and Lock (37) reported that all three studies measuring fat intake found significant decreases in total fat or saturated fat, and both studies measuring fruit and vegetable intake showed a positive impact. Three out of four studies that examined the effect of policies on menu composition showed a significant decrease in total fat and saturated fat on the school menus. All four studies of interventions to increase fruit and vegetables offered at school lunch showed that guidelines led to increased fruit and vegetable availability. Both studies that measured the impact of restrictive nutrition policies on sales of food and beverages suggested a significant but limited decrease in the sales of banned foods, such as chips and SSBs; and both studies that measured the impact of reducing low-fat food prices showed significant increases in low-fat snacks and fruit and vegetable sales. Only one study reported effects on BMI, but found no difference after 1 year of follow-up.

In 2015, Afshin et al. (40) reviewed the evidence for specific policies to improve dietary habits and reduce cardiovascular and metabolic risk factors, including 76 studies of school regulation and procurement policies. Among 31 studies to increase the availability of healthy foods and beverages — such as fruit and vegetables, low-fat snacks, milk, whole grain products or water — the interventions that aimed to increase fruit and vegetable intake appeared effective. As noted in essential criterion 1.1, the 26 studies on restrictions to unhealthy foods and beverages in schools through bans or nutrient standards for competitive foods appeared generally effective in reducing intake of unhealthy competitive foods and beverages and decreasing incidence and prevalence of overweight/obesity, and more so in governmental and school

policies than in voluntary programmes. However, among 22 studies on the effect of standards based on food, nutrients or portion size for lunch and/or breakfast, results were inconsistent across studies and no consistent patterns were identified to explain the heterogeneous findings. The authors concluded that changes in school procurement policies appear effective for either increasing healthy or reducing unhealthy choices, while setting of nutrition standards has less consistent benefits.

In the United States, Mansfield and Savaiano (43) in 2017 reviewed 31 studies of the U.S. National School Lunch Program nutrition standards under three different legislative eras and concluded that increasing access to healthy foods during school lunch improved students' dietary intakes. Improved food consumption behaviours — including increased selection, intake and sales of healthy foods, and decreased plate waste — were reported in 14 of the 19 intervention and longitudinal observation studies. However, only two of the 12 one-time observation studies reported food consumption behaviours meeting target school nutrition standards.



The five reviews which were not described under essential criterion 1.1 (because the status of policy was not clear) also found positive effects of school food standards or other measures to improve the availability of foods and beverages in schools on diet-related outcomes (79, 124, 131, 151, 152). In a 2014 systematic review of 34 food procurement policy and programme studies, Niebylski et al. (151) found all the 19 studies conducted in the school setting demonstrated increases in healthy food purchasing. Furthermore, many of the school interventions that included an additional education component were effective at increasing the intake of healthy foods and decreasing intakes of foods high in fat, sodium or sugar. This review also included two school-based studies that assessed health outcomes, and these found reductions in blood pressure and BMI. In the 2015 systematic review of 102 quantitative and qualitative studies of school architecture and design described under essential criterion 3.1, Frerichs et al. (124) found improved dietary behaviours, as measured by sales, self-reported data or plate waste, from 12 of 16 studies of increased accessibility of healthy items or

decreased accessibility of less healthy items. On the other hand, studies on the effect of different foods in vending machines had mixed results.

In the 2006 systematic review of 15 fruit and vegetable promotion interventions described under essential criteria 1.1, 2.2, 2.3 and 3.1, Knai et al. (79) reported six out of nine studies with increased exposure to fruit and vegetables in the school setting (e.g. canteens) and six out of 10 studies modifying lunches or snacks provided had significant positive results on consumption. In the 2019 systematic review of 29 various school-based studies in adolescents described under essential criterion 3.1, Calvert, Dempsey and Povey (131) noted that increased availability of healthy foods in school was a promising intervention component and improved healthy eating outcomes in all six studies with this component. In a 2008 systematic review of 22 school-based obesity prevention or reduction studies in China, Li et al. (152) found that 10 of the 13 studies that included a dietary modification component (e.g. increase vegetable, fruit, legumes; restrict SSBs; portion size control) reported on weight-related outcomes and all of these studies reported effectiveness on overweight/obesity prevalence and/or BMI.

Two systematic reviews looked at the set-up of school cafeterias rather than the content of the menus (136, 153). In the 2018 systematic review of 48 school cafeteria environment studies mentioned under essential criterion 3.1, Gordon, Dynan and Siegel (136) found that interventions that change the environment to favour fast and intuitive thinking for selecting healthier options were both more common and more effective than interventions that favour slow and cognitively-demanding choices through educating children. Using behavioural economics theory, they characterized school cafeterias and approaches to improving nutrition into “system 1”



characterized as “fast and intuitive thinking” (e.g. price changes, placement) and/or “system 2” characterized as “slow and cognitively demanding” (e.g. nutritional education, information posting), and assessed the impact on nutrition-related outcomes (e.g. BMI, consumption and/or selection of fruit, vegetables, sugary drinks, plain milk and/or whole grains). The authors found that 89% of 27 “system 1” studies were successful, compared to 62% of 13 mixed “system 1” and “system 2” studies and 50% of eight “system 2” interventions. “System 1” studies were significantly more effective than “system 2” studies ( $P = 0.033$ ). In another systematic review of 12 studies on the effects of choice architectural nudging interventions on adolescent vegetable consumption where diet-related behaviour is influenced without limiting choice sets or making alternatives costlier (e.g. provision of free vegetables, serving styles and changes in the physical environment), Nørnberg et al. (153) in 2016 found overall inconclusive results. They noted that providing free vegetables resulted in more favourable attitudes towards vegetable consumption, and offering a greater variety of vegetables resulted in increased vegetable consumption.

Six meta-analyses (59, 67, 116, 148-150) and nine reviews (37, 44, 76, 77, 135, 154-157) considered the provision of foods, beverages or snacks such as fruit and vegetables in schools. Among these, two meta-analyses (67, 148) and four reviews (76, 154-156) analysed school feeding programmes, two meta-analyses (149, 150) and one systematic review (157) examined the effect of micronutrient fortification of foods or beverages provided in schools, while three meta-analyses (59, 116) and four systematic reviews (37, 44, 77, 135) examined fruit and vegetable schemes in schools.

Regarding school feeding programmes, one meta-analysis focused on disadvantaged children in low-resource settings in the context of undernutrition (148), while another focused

on school lunch and breakfast programmes in the context of obesity reduction (67). Both meta-analyses showed mixed results. In a 2007 Cochrane review and meta-analysis of 18 studies in schools in disadvantaged settings in low- and higher- and lower-income countries, Kristjansson et al. (148) found that school meals may have some small benefits for nutrition-related outcomes. Evidence from the highest quality studies (RCTs) from low-income countries found that children who were fed at school gained more weight than controls over an average study duration of 19 months (+0.39 kg; 95% CI: 0.11, 0.67). In the lower quality studies (controlled before and after trials), children who were fed at school also gained more weight than controls over an average study duration of 11.3 months (0.71 kg; 95% CI: 0.48, 0.95). For height, results were mixed; in RCTs, differences in gains were significant only for younger children (+0.40cm; 95% CI: 0.03, 0.77), whereas the results from the controlled before and after trials were large and significant overall (+1.43cm; 95% CI: 0.46, 2.41). Positive results were also noted for school attendance and educational and cognitive outcomes. Results from higher-income countries were mixed, but generally positive. In the 2013 systematic review and meta-analysis on the effect of school diet and physical activity policies on child obesity in the United States described above, Williams et al. (67) found that participation in the U.S. National School Lunch Program targeted at children at risk of undernutrition was associated with a non-significant rise in BMI z-score, while participation in the School Breakfast Program, also targeted at children at risk of undernutrition, was associated with a significantly lower BMI z-score (-0.08; 95% CI: -0.143, -0.017).

Of the four reviews on school feeding programmes, three were conducted in low- and middle-income countries (154-156) and one was conducted in a high-income country but with many studies targeted at disadvantaged children (76). In 2015 Watkins et al. (154) did a literature review of



10 school feeding programme studies in primary schools in low- and middle-income countries in Africa, Asia and Latin America. Among the 10 studies measuring anthropometric outcomes, small but significant improvements were seen in height/stunting in seven of the studies and on weight/underweight in six of the studies. Nearly all the food supplementation studies that reported significant height and weight gains included an animal-based product not usually included in school feeding programmes in low-income countries. Spillover benefits were observed for younger siblings, indicating that school feeding could have an important role in promoting the health of the next generation. Incorporating findings from other related systematic reviews, the authors concluded that the largest effects were seen for in-school meals on height/stunting, weight/underweight and for multiple micronutrient fortification on iron status, anaemia/haemoglobin, vitamin A

status and zinc status. Take-home rations, multiple micronutrient fortification or powder had some effect on height/stunting and weight/underweight, whereas in-school meals and micronutrient powders had some effect on various micronutrient-related outcomes.

In 2008 Adelman, Gilligan and Lehrer (155) reviewed 20 studies of food-for-education programmes (e.g. breakfast, mid-day meal, micronutrient fortified meals/snacks, animal-source foods) implemented in primary schools in low- and middle-income countries in Africa, Asia and Latin America. Three of four studies measuring consumption-related outcomes found that school feeding increased caloric intake among school-aged children, particularly when the baseline was well below their age- or weight-recommended consumption level. Furthermore, three of four studies found that increasing access



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to calories over a sufficient period increased body size or composition (e.g. height, weight, BMI, mid-upper arm circumference (MUAC)). However, provision of micronutrient-rich foods or deworming seemed to have contributed to improvements in some outcomes (e.g. height, MUAC). Improvements were typically small, but the authors note that the effect may have been mitigated by increased activity levels. Iron status was improved as a result of fortified school meals in three out of four studies, vitamin B12 status was improved as result of meat-based meals in one study, vitamin A was improved as result of vitamin A fortification in one out of two studies, prevalence of iodine deficiency disorders (IDD) was reduced as result of iodine fortification in one study. Similar conclusions were drawn by Jomaa, McDonnell and Probart (156) in a 2011 review of 13 school feeding programmes in low- and middle-income countries, including meals based on staples, snacks, fortified snacks and drinks. The authors found positive effects on energy intake, micronutrient status, school enrolment and attendance of children

participating in school feeding programmes compared to non-participants.

As described in essential criterion 1.1, Colley et al. in 2019 (76) found that multicomponent school food programmes in Canada — many of which were implemented in indigenous communities or targeted at disadvantaged children — were positively associated with children’s development of nutrition knowledge in four out of six studies which measured it, with changes in dietary behaviour and food preferences in all seven studies measuring this and in intake of healthy foods in six out of eight studies which assessed intakes.

The effects of micronutrient fortification of foods or beverages provided in schools were reviewed in two meta-analyses (149, 150) and three systematic reviews (154, 155, 157), which all found beneficial effects on micronutrient status and sometimes on anthropometric outcomes. In the 2017 Cochrane review and meta-analysis by De-Regil, Jefferds and Peña-Rosas (149)

underpinning the WHO guideline (144) on point-of-use fortification with micronutrient powders (MNP) in preschool- and school-age children, eight out of 13 studies included were conducted in the school setting among low- and middle-income populations in Asia, Africa and Latin America. The overall results from the meta-analysis found lower risk of anaemia (prevalence ratio (PR): 0.66; 95% CI: 0.49, 0.88) and iron deficiency (PR: 0.35; 95% CI: 0.27, 0.47) as well as higher haemoglobin (MD: +3.37 g/L; 95% CI: +0.94, +5.80) among preschool- and school-age children receiving iron-containing MNP for point-of-use fortification of foods. In a 2015 systematic review and meta-analysis of multiple micronutrient-fortified non-dairy beverage interventions in school-aged children in low- and middle-income countries, Aaron, Dror and Yang (150) found positive effects of multiple micronutrient-fortified beverages on haemoglobin (+2.76 g/L; 95% CI: +1.19, +4.33) and serum ferritin (+15.42 pmol/L; 95% CI: +5.73, +25.12); as well as reduced risk of anaemia (RR: 0.58; 95% CI: 0.29, 0.88), iron deficiency (RR: 0.34; 95% CI: 0.21, 0.55) and iron deficiency anaemia (RR: 0.17; 95% CI: 0.06, 0.53). Furthermore, they found a moderate but significant effect for weight gain in the intervention group compared with the control (+0.30 kg; 95% CI: +0.01, +0.58), but neither height nor weight-for-age or height-for-age Z-scores were significantly different between groups.

In a 2011 systematic review of 12 studies to examine the effects of multiple micronutrient fortification in the school setting, Best et al. (157) found that such fortification, with the exception of zinc, improved micronutrient status in 10 of 11 intervention groups. However, the impacts of multiple micronutrient fortification on functional health outcomes, such as growth, morbidity and cognitive development, was inconsistent. Four of seven studies reported a significant beneficial effect on weight gain, increased BMI or MUAC, but only two showed an effect on height. Four of seven studies showed some

beneficial effects on children's health including reduced incidence or duration of diarrhoea and respiratory diseases. The impacts on cognitive performance were inconsistent and varied between cognitive domains (e.g. memory, fluid intelligence, school performance), whereas the impact on working memory across studies was more positive. As described above, the 2015 literature review by Watkins et al. (154) noted the largest effects for, among other things, multiple micronutrient fortification on iron status, anaemia/haemoglobin, vitamin A status and zinc status. Multiple micronutrient fortification or powder also had some effect on height/stunting and weight/underweight, whereas micronutrient powders had some effect on various micronutrient-related outcomes. Also described above, Adelman, Gilligan and Lehrer (155) noted that iron status was improved as result of fortified school meals in three out of four studies, vitamin A status was improved as result of vitamin A fortification in one out of two studies, and prevalence of IDD was reduced as result of iodine fortification in one study.

Finally, the effect of providing fruit and vegetables through schools was reviewed in three meta-analyses (36, 44, 59, 116) and four systematic reviews (37, 44, 77, 135). In their 2018 systematic review and meta-analysis of 91 school food environment policies mentioned above, Micha et al. (36) found from 40 studies of direct or indirect provision of healthy food policies (largely targeting fruit and vegetables) that positive effects were seen on consumption of fruits (+0.27 servings/day; 95% CI: +0.17, +0.36), fruits and vegetables (+0.28 servings/day; 95% CI: +0.17, +0.40) and vegetables (+0.04 servings/day; 95% CI: +0.01, +0.08). No effect was seen on total calorie intake, water consumption or any adiposity or metabolic measures from the provision policies. In a 2012 systematic review and meta-analysis of 27 school-based interventions to improve daily fruit and vegetable intake in children aged 5–12 years by

Evans et al. (59), 10 of the studies included free school fruit and vegetable distribution or fruit and vegetable subscription programmes either alone or along with other components. While it is not possible to separate the effect of these various components from other changes, the meta-analysis of 21 studies found that fruit and vegetable intake increased (+0.25 portions/day; 95% CI: +0.06, +0.43), mainly due to increases in fruit consumption. Separate analyses for fruit and vegetable consumption showed a significant increase in fruit (+0.24 portions/day; 95% CI: +0.05, +0.43) but a non-significant increase in vegetables. On the other hand, a 2011 systematic review and meta-analysis by Delgado-Noguera et al. (116) of 19 studies on primary school interventions to promote fruit and vegetable consumption found no significant effect of free or subsidized fruit and vegetables in a pooled analysis of two of three such programmes studied with a RCT design.

In the systematic review of 27 studies of school food and nutrition policies by Jaime and Lock (37) described above, four studies measuring the impact of providing free or subsidized fruit and vegetables showed a statistically significant increase in fruit and vegetable consumption. In the 2010 systematic review of 42 European school-based interventions to promote a healthy diet described under essential criterion 3.1, Van Cauwenberghe et al. (135) found that all five studies on fruit and vegetable provision programmes increased fruit and vegetable consumption. However, only one study showed a lasting effect. Similarly, in a 2008 systematic review of 30 school fruit and vegetable programmes, 10 of which included free or subsidized fruit and vegetables

amongst other components (e.g. classroom activities, school policies, involvement of teachers, peer leaders, parents, community and school food service), de Sa and Lock (77) found that 70% of studies reported positive associations between interventions and nutrition outcome. Two of the national programmes providing free or subsidized fruit and/or vegetables had been evaluated and had shown significant increase consumption during the scheme, with one of them also showing sustained increases after the scheme finished. In the 2019 Cochrane review of interventions to reduce SSB consumption mentioned above, von Philipsborn et al. (44) found that both studies measuring impact of fruit and vegetable provision on SSB consumption reported a significant effect, however, the overall quality of evidence was judged as very low certainty.





*Essential criterion 4.2: Positive messaging towards nutrition and active living*

Two meta-analyses (92, 115) and seven reviews (35, 44, 105, 124, 136, 158, 159) were identified that considered implicit or explicit messaging, incentivising desired behaviour or specific labelling to encourage healthy eating. Many other reviews included studies with an element of positive messaging toward nutrition and active living — often as part of nutrition education activities — but the review authors seldom analysed the effect of this specifically.

In the 2015 systematic review and meta-analysis by Dudley, Cotton and Peralta (92) of teaching strategies to promote healthy eating in primary school children described under essential criteria 2.2 and 3.1, four of the included studies used contingent reinforcement (i.e. reward for behaviour), and all four of the studies reported statistically significant results. Based on the two studies that

reported effect sizes, the average effect size for contingent reinforcement in promoting fruit and vegetable consumption or preference was  $Md = 1.34$ . Although this is a large effect size ( $> 0.4$  is considered a large effect), more studies are needed to determine the average effect size with less variance. In the 2018 meta-analysis of 30 studies aiming to increase vegetable intake in children 2–5 years of age described under essential criteria 3.1 and 4.1, 24 of which were conducted in preschool or child care settings, Nekitsing et al. (115) found a small-to-moderate effect (Hedge's  $g = 0.40$ ) from pooling results of 30 studies and a slightly higher effect ( $g: 0.42$ ; 95% CI: 0.33, 0.51,  $P < 0.001$ ) from pooling results of all 44 intervention arms. In subgroup analyses of intervention strategies, the studies using taste exposure had a significantly higher impact on intake ( $g: 0.79$ ; 95% CI: 0.53, 1.05) than food service modifications alone ( $g: 0.30$ ; 95% CI: 0.10, 0.50), especially when coupled



with reward and modelling in studies (g: 1.08; 95% CI: 0.50, 1.66), with the largest effect size observed for unfamiliar/disliked vegetables.

In the 2018 systematic review of 48 school cafeteria environment studies described under essential criteria 3.1 and 4.1, Gordon, Dynan and Siegel (136) found that messaging that support fast and intuitive thinking for selecting healthier options appeared effective. Nine of 11 studies using incentives were successful, as were all five studies using emoticons, whereas one out of three studies using messaging was effective. However, the authors noted that as the latter was a single component study, this demonstrates that messaging alone may significantly increase consumption of vegetables. In the 2019 systematic review of 33 natural experiments for childhood obesity prevention and control described under essential criteria 1.1 and 4.1, Bramante et al (35) found that the four studies of multicomponent interventions in the school setting focusing on food/beverage and physical activity/built environments had favourable BMI outcomes. Two of these four studies that also focused on healthy messaging achieved the largest improvement in BMI. Similarly, in 2017, Black, Matvienko-Sikar and Kearney (105) also noted that effective school-based programmes to improve children's diet and health incorporated role-models including peers, teachers and heroic figures, as well as rewards for healthy eating and increased access to healthy foods in their systematic review of 39 school-based diet and physical activity interventions described under essential criterion 2.2.

In the 2019 Cochrane review of interventions to reduce SSB consumption described under essential criterion 4.1, von Philipsborn et al. (44) found low certainty evidence that prizes and tokens or emoticons may be effective. All three studies reported that small prizes and token rewards for the selection of plain milk in elementary school cafeterias were associated with decreased selection of sugar-sweetened milk, though the effect on total

milk selection varied. They also identified one study that found a positive effect of emoticon (smileys) labels on plain milk and small prizes in reward for selecting such milk over sugar-sweetened milk. The authors noted that this may drive up food waste if children choose the plain milk but do not drink it. In a 2011 systematic review of 30 school-based studies, Jensen et al. (158) found that economic incentives may influence school children's choice of foods, snacks and beverages. In particular, direct price incentives were effective for altering consumption in school cafeterias or from vending machines and for increasing fruit/vegetable consumption in schools, in contexts where foods or beverages are offered (for sale) in schools and students (typically 10–12 years or older) bring money to school to buy some of these items. The authors were not able to assess the effectiveness of small rewards — such as pens, other small items or participation in a raffle — for healthier food choices, since such interventions were usually implemented in combination with extensive educational activities.

In 2017 Sacco et al. (159) conducted a systematic review of 11 real-world and artificial studies on the effect of menu labelling on food choice of children aged between 6 and 18 years. The studies of hypothetical food purchases in artificial environments suggest that menu labelling may be efficacious in reducing calories purchased for or by children and adolescents. The real-world studies were less supportive, although two of the three school-based studies suggested a potential impact of utilizing menu labelling in school cafeterias. In the 2015 systematic review of 102 quantitative and qualitative studies of school architecture and design described under essential criteria 3.1 and 4.1, Frerichs et al. (124) found evidence from analysis of 15 studies of educational signage, wayfinding and marketing, that these approaches are acceptable strategies to students, parents and teachers for addressing healthy eating in schools, though results were mixed and often not sustained.

*Essential criterion 4.3: Absence of marketing of foods and beverages at school*

WHO developed a set of 12 recommendations, endorsed by the Sixty-third World Health Assembly in 2010, aimed at reducing the impact of marketing foods high in saturated fats, trans-fatty acids, free sugars or salt to children (160). The Recommendations recognize that “the nutritional well-being of children within schools should be paramount and the foundation stone for children’s well-being at this formative age” and recommends that such “settings where children gather should be free from all forms of marketing of foods high in saturated fats, trans-fatty acids, free sugars, or salt.” (160) This includes marketing of foods and beverages as well as promotions or sponsorships, during or outside of school hours (161).

Several reviews have demonstrated how marketing of unhealthy foods and beverages to children are widespread across the world and are influencing their food preferences, purchase requests and/or consumption patterns (162-166). For this review of reviews, however, only one review was identified that specifically examined marketing in schools. This 2017 review by Velazquez, Black and Potvin Kent (167) of 27 studies of food and beverage marketing in schools found that students are commonly exposed to food and beverage marketing through a variety of strategies, especially in secondary schools and schools with lower socioeconomic status. Marketing exposure is often associated with food purchasing and consumption, especially for food items of low nutritional quality (e.g. salty snacks, sweet confectionery, SSBs). Furthermore, many schools do not have, or are not subject to, laws, policies or guidelines regulating such marketing. Two studies evaluating compliance with laws or policies restricting school food and beverage marketing found numerous instances of non-compliant marketing.

*Essential criteria 4.4: Access to an adequate eating place and 4.5: Adequate school cooking facilities*

The WHO School Policy Framework (147) provides some suggestions regarding food service areas. School food service areas should be friendly, welcoming and consist of multiple points of service in cafeterias to avoid long queues and give students time to choose foods. In addition, they should provide a clean eating area and food ought to be provided in a non-stigmatizing manner, especially to students participating in free or reduced-price meal programmes.

Maintaining adequate eating and cooking spaces is also an important factor in prevention of foodborne illness and diarrhoeal disease in schoolchildren. This is particularly important because diarrhoeal disease can exacerbate undernutrition, while children who are malnourished are more susceptible to infection (168). Cooking spaces should include all the necessary facilities to adhere to



*WHO's Five Keys to Safer Food:* 1) Keep clean, 2) Separate raw and cooked, 3) Cook thoroughly, 4) Keep food at safe temperatures, and 5) Use safe water and raw materials (108). Ensuring the proper handling of food is an essential step in the provision of safe and nutritious foods to children in schools.

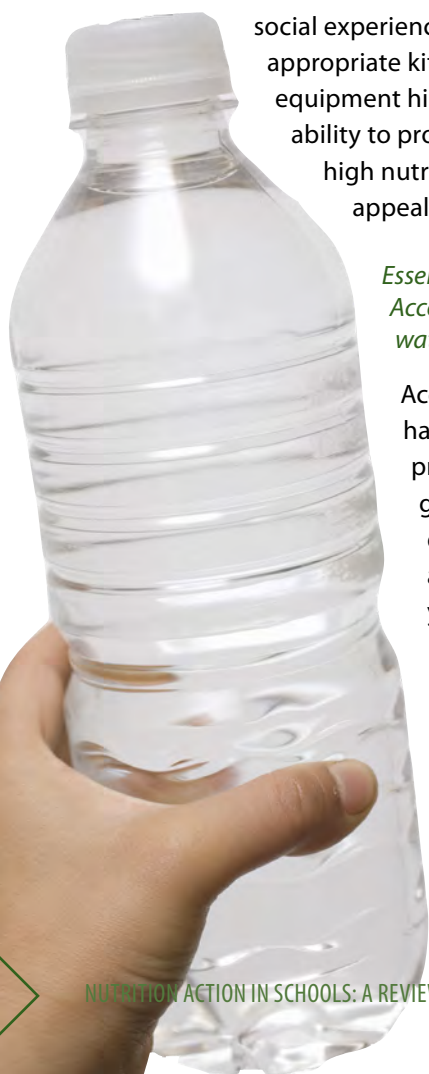
One review was identified that specifically examined studies related to eating places and cooking facilities in schools. In this 2015 systematic review of 102 quantitative and qualitative studies of school architecture and design described under essential criteria 3.1, 4.1 and 4.2, Frerichs et al. (124) found evidence that a range of physical factors contribute to creating supportive school environments for healthy eating. Analysis of studies of the dining or kitchen domain found that overcrowding in the cafeteria contributed to students' negative social experiences, while lack of appropriate kitchen facilities and equipment hindered schools' ability to provide meals with high nutritional quality and appeal.

*Essential Criterion 4.6:  
Access to safe drinking  
water*

Access to safe water has been a high priority on the global health and development agenda for years, first in the Millennium Development Goals and now as one of the Sustainable Development Goals (SDGs).

Goal six of the SDGs is to ensure access to water and sanitation to all, with a specific target (6.1) for universal and equitable access to safe and affordable drinking water (169). Given the significant time children spend at school, it is important that they have access to adequate sanitation and safe drinking water. The WHO WASH standards for schools in low-cost settings highlight some of the positive effects including reduced disease burden, more effective learning, gender equity and an opportunity to learn and practice lifelong hygiene behaviours (170).

Three systematic reviews were identified that analysed aspects of access to safe drinking water relating to nutrition outcomes (44, 124, 171). In a 2012 review of 47 water and sanitation studies in schools, Jasper, Le and Bartram (171) identified a subset of 11 studies focused on access to clean drinking water. Of the 11 studies, three noted a statistically significant increase in water consumption when children had free access to water in schools. One of the RCTs included from Europe reported a 31% reduction in the risk of overweight associated with providing drinking water and education in schools. In the 2019 Cochrane review of interventions to reduce SSB consumption described under essential criteria 4.1 and 4.2, von Philipsborn et al. (44) found four studies that improved availability of drinking water in schools as part of their school nutrition standards. Two of these studies reported significant effect on total intake of SSBs or sugar-sweetened milk, though there was indication that improved water availability may decrease total milk selection. Furthermore, two out of three studies that also measured weight-related outcomes reported significant beneficial effects. In the 2015 systematic review of 102 quantitative and qualitative studies of school architecture and design described in essential criteria 3.1, 4.1, 4.2, 4.4 and 4.5, Frerichs et al. (124) found that six of nine studies on water access found improvements in water intake, but not in terms of reduced SSB consumption.



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*Essential criterion 4.7: Promotion of safe hygiene and sanitary behaviour*

One of the guidelines in the WHO standards for WASH in low-cost school settings pertains to hygiene promotion (170). The correct use and maintenance of water and sanitation facilities is ensured through sustained hygiene promotion and used as resources for improving hygiene behaviours. Hygiene education ought to be provided to teachers and schoolchildren, and positive hygiene behaviours should be systematically promoted throughout the school setting through clear rules and the participation of school staff, students and parents. WHO also recently released guidelines on sanitation and health, where schools are mentioned as an important setting where access to safe toilets should be ensured, and the rationale provided includes nutritional outcomes (172).

UNICEF supports efforts to provide every child with the benefits of clean water for drinking and washing, dignity and safety through ample toilets and washstands (separated for girls and boys), education for good hygiene and healthy school environments through safe waste disposal. UNICEF finds that providing schoolchildren with access to drinking water, sanitation facilities and hygiene education is associated with educational and health benefits for both schoolchildren and the greater community (173).

One meta-analysis (174) and one systematic review (171) that analysed the effectiveness of interventions to promote good sanitation and hygiene in the school setting in relation to nutrition-related outcomes were identified. In a 2015 Cochrane review and meta-analysis of 22 RCT studies, of which 12 were conducted in child day-care centres or schools, Ejemot-Nwadiaro et al. (174) found that handwashing promotion prevented about one third of diarrhoea episodes in these settings (RR: 0.70; 95% CI: 0.58, 0.85). Most of these studies were from high-income



countries, but the authors suggest that the intervention may also prevent a similar burden of diarrhoea in middle- and low-income countries based on the result of two trials from urban areas in such countries (RR: 0.66; 95% CI: 0.43, 0.99). In the 2012 systematic review of 47 water and sanitation interventions in schools described under essential criterion 4.6 above, Jasper, Le and Bartram (171) found that two of three RCT studies aimed at improving handwashing and three of six studies providing water for both drinking and handwashing reported reduced illness and absenteeism as a result of the intervention. Furthermore, scarce supplies (e.g. water, soap, paper towels, etc.) were commonly reported to be associated with less handwashing.

*Essential criterion 4.8: Availability of clean and separate toilets, for boys and girls*

WHO standards for school water and sanitation include a guideline pertaining to toilet facilities, indicating that they should be private, secure, accessible, clean and culturally appropriate (170). Under this guideline, it is advised that male and female toilets be completely separated.

While reviews exist that consider separation of toilet facilities in schools or adequate facilities for females, no review was identified that considered outcomes relevant to nutrition. Thus, no reviews were identified for essential criterion 4.8 (Availability of clean and separate toilets, for boys and girls).

*Essential criterion 4.9: Opportunity for all age groups to access space and school sporting facilities for physical activity in and outside of curriculum*

WHO recommends that adequate facilities are available on school premises and in public spaces for physical activity during recreational time for all children (28, 137). Two reviews examined the effects of space for physical activities, within and outside of the school curriculum.

While reviews exist that consider the built environment for physical activity in school, these were not conducted in relation to school-based nutrition programmes. Thus, no reviews were identified for essential criterion 4.9 (Opportunity for all age groups to access space and school sporting facilities for physical activity in and outside of curriculum).

*Essential criterion 4.10: Affirmative action against bullying, stigmatization and discrimination*

Interventions to reduce bullying, stigmatization and discrimination are important for improving the school environment and student well-being, and many reviews have been conducted on these issues. However, no reviews were identified that examined such interventions in the context of diet or nutrition. Thus, no reviews were identified for essential criterion 4.10 (Affirmative action against bullying, stigmatization and discrimination).

*Essential criterion 4.11: School staff as role-models in encouraging healthy eating and healthy lifestyle*

While many of the reviews included school staff and teachers in the implementation of health interventions, few reviews specifically examined the effectiveness of using school staff as role-models. Most evidence exists in demonstrating the influential role of parents and families in modelling healthy lifestyle, as discussed under essential criterion 2.2.

One meta-analysis (117) and two systematic reviews (99, 105) were identified that discussed evidence for modelling healthy dietary behaviours improving intervention effectiveness. In the 2017 systematic review and meta-analysis of 40

interventions to reduce SSB consumption and obesity – 15 of which were school-based — by Vargas-Garcia et al. (117) described under essential criterion 3.1, there was evidence that modelling or demonstrating the behaviour helped to reduce SSB intake in children. Univariate meta-regressions showed that modelling was associated with greater effectiveness in reducing intakes across all age groups (-124 mL/day; 95% CI: -221, -27) and in children specifically (-173 mL/day; 95% CI: -315, -31).

In the 2012 systematic review of 12 obesity prevention studies in children aged 4–6 years described under essential criteria 2.2 and 3.3, Nixon et al. (99) found that interventions with the highest levels of success involved modelling healthy eating and physical activity. Although the study interventions focused on parental modelling of healthy diet behaviours, it is suggested that teachers could also be influential role-models in shaping young children's perceptions of healthy living. Similarly, Black, Matvienko-Sikar and Kearney in 2017 (105) also noted that effective school-based programmes to improve children's diet and health incorporated role-models including peers, teachers and heroic figures, as well as rewards for healthy eating and increased access to healthy foods, in their systematic review of 39 school-based diet and physical activity interventions described under essential criteria 2.2 and 4.2.

***NFSI component 5: Providing supportive school nutrition and health services***

NFSI component 5 concerns the services that schools may provide to support nutrition and health, in relation to detecting nutrition problems and as a delivery channel for nutrition interventions.

Some evidence was identified that reviewed growth monitoring and screening for overweight and obesity. Some evidence was also identified for nutrition interventions delivered through school health services, such as micronutrient supplementation, deworming and counselling for overweight and obesity.

## NFSI component 5: Providing supportive school nutrition and health services


- One meta-analysis and one review examined regular monitoring and feedback on children's growth relevant to essential criteria 5.1 and 5.2.
- School-based weight monitoring and guidance was found to be effective in treatment of overweight and obesity in children. School-based screening programmes were also found to be useful in obesity prevention programmes, reporting positive effects in both children and their families.
- Three meta-analyses were identified relevant to essential criterion 5.3 examining the impact of delivering nutrition interventions through school health services. Two of these were conducted in low- and middle-income countries.
- School-based delivery of micronutrient supplementation had positive effects on micronutrient status, including anaemia, iron and zinc status.
- School-based deworming had positive effects on haemoglobin and anaemia, especially when combined with hygiene promotion and/or co-administration of iron and retinol.
- Counselling by school health nurses as part of school-based obesity prevention and treatment reduced BMI in children.

### *Essential criteria 5.1: Regular monitoring of children's growth development and 5.2: Effective feedback system for parents and children of findings of the regular monitoring*

Regular monitoring of children's growth and development using tools such as the *WHO Growth Reference for children and adolescents 5–19 years* (175) can help identify underweight, overweight and obesity, as well as other growth-related conditions.

One meta-analysis (56) and one review (176) were identified that examined the impact of school-based growth monitoring and BMI screening programmes. In the 2017 systematic review and meta-analysis of 76 school-based obesity treatment and prevention studies in China described under essential criteria 1.1 and 3.2, Feng et al. (56) found that multicomponent interventions were more successful than single component interventions. All four of the studies combining health education with weight management, which included weight

monitoring and guidance among overweight and obese children, were effective in improving weight-related outcomes. In a 2015 review of 21 mandatory, school-based BMI screening programmes in the United States, Ruggieri and Bass (176) found that screening programmes can be valuable as part of school-based obesity prevention programmes and promotion of healthy lifestyles in schools. Despite confidentiality concerns shared by parents, school nurses and school administrators, most parents were supportive, provided that respect for student privacy was maintained at all levels. BMI screening and referral lead to increased follow-up action by parents in some studies, whereas other studies reported that only a small percentage of parents actually took action. Other reported outcomes were reduced use of diet-pills, encouraging a healthy breakfast, limiting family consumption of unhealthy foods and beverages, decreasing family meals in fast food restaurants, limiting unhealthy fats for meals cooked at home, limiting children's screen time, giving more time for physical activity and reducing use of



physical activity as punishment. One study reported stabilization of BMI over the years of the programme. Resources that are required — for staff, measurement tools, obtaining parental permission and reporting data — were reduced by introducing biennial rather than annual screening.

***// School-based weight monitoring and guidance was found to be effective in treatment of overweight and obesity in children. School-based screening programmes were also found to be useful in obesity prevention programmes, reporting positive effects in both children and their families //***

*Essential criterion 5.3: A supportive school health service, including a referral system*

School health services, a key feature of the WHO Health Promoting Schools approach, may provide a range of supportive nutrition interventions, such as micronutrient supplements or anthelmintic treatment, depending on the country context.

WHO recommends iron or iron and folic acid supplementation for the prevention of anaemia and iron deficiency in areas where anaemia is a public health problem. Daily supplementation is recommended for school-age children (177) and adolescent girls (178) in settings where anaemia prevalence is 40% or higher. In settings where anaemia prevalence is 20% or higher, intermittent (e.g. weekly) supplementation is recommended for both school-age children (179) and adolescent girls (180). The guidelines for school-age children (5–12 years) acknowledge schools as an appropriate

delivery platform and entry point to reach that age group, however, there also needs to be consideration of how to reach children outside of the school system. The guidelines pertinent to adolescent girls also make reference to schools as a potential delivery system, but this is less specific, probably because they cover adult women as well.

WHO also recommends anthelmintic treatment (deworming) as a public health intervention for school-age children and adolescent girls living in areas where the baseline prevalence of any soil-transmitted infection is 20% or more among these target groups, in order to reduce the worm burden of soil-transmitted helminth infection (181). School-based programmes are considered particularly feasible, as it is easy to deliver medicines through teaching staff, with estimated costs varying from USD 0.03 to 0.13 per child per year (182). Traditionally, many countries have used school-based deworming programmes, which should be implemented along with more long-term solutions to prevent soil-transmitted helminth infections such as improvements in water, sanitation and hygiene.

Supportive school health services extend beyond deworming and micronutrient supplementation programmes. School health services are involved in regular growth monitoring, can provide counselling on nutrition and diet and make referrals as needed.

Three meta-analyses and one review were identified that examined nutrition-related school health services. Two of the meta-analyses reviewed the provision of micronutrient supplements in schools (183, 184), one meta-analysis reviewed school-based deworming (184) and one meta-analysis (88) and one review (132) examined nutrition counselling or education by health workers.

Regarding the provision of micronutrient supplements in schools, Salam et al. in 2016 (183) reviewed 30 studies of micronutrient supplementation



in adolescents in low- and middle-income countries and found a significant decrease in anaemia prevalence (RR: 0.69; 95% CI: 0.62, 0.76). Further subgroup analysis showed that school-based delivery significantly reduced anaemia (RR: 0.67; 95% CI: 0.60, 0.74). School-based delivery of iron or iron/folic acid supplementation (alone or in combination with other micronutrients) was also associated with improved serum haemoglobin (MD: +1.94 g/dL; 95% CI: +1.48, +2.41), ferritin (MD: +3.80 mcg/L; 95% CI: +2.00, +5.59) and iron (MD: +6.97 mmol/L; 95% CI: +0.19, +13.76). Zinc supplementation also improved serum zinc concentrations (MD: +0.96 mcg/dL; 95% CI: +0.81, +1.12). Furthermore, in the 2018 systematic review and meta-analysis of eight school-based deworming programmes described immediately below, Girum and Wasie (184) noted that micronutrient supplementation may enhance the effect of deworming.

Regarding school-based deworming, Girum and Wasie (184) did in 2018 a systematic review and meta-analysis of eight school-based deworming programmes involving 1 005 239 children. They found an overall improvement in haemoglobin after deworming, with best impact on anaemia rates in studies that combined deworming with hygiene promotion and/or co-administration of iron and retinol. Meta-analysis of five studies found an overall improvement in haemoglobin after deworming (+1.62 g/dL; 95% CI: +1.01, +2.25).

On nutrition counselling or education delivered by health workers in the school setting, the 2016 systematic review and meta-analysis of 11 childhood obesity prevention or treatment interventions delivered by school health nurses described under essential criterion 2.2 by Schroeder, Travers and Smaledone (88) found positive effects of involving school health nurses in anthropometric measurement and additional activities such as student education and counselling, involvement of parents, staff education or physical activity. The pooled results showed small but significant changes in BMI (-0.48



kg/m<sup>2</sup>; 95% CI: -0.84, -0.12), BMI z-score (-0.10; 95% CI: -0.15, -0.05) and BMI percentile (-0.41; 95% CI: -0.60, -0.21). Although the findings suggest that school health nurses can play a role in implementing successful school-based health programmes, the authors highlight several barriers to involving them including lack of confidence in counselling methods and understaffing due to budgetary constraints. In contrast, the USDA (132) in 2012 in examining the effect of different types of educators as part of the series of systematic reviews on nutrition education described in essential criterion 3.1, noted that the changes in dietary intake among school children were significantly greater in the teacher-educated group compared to the nutritionist-educated group. However, this was based on assessment of one single study, which was considered insufficient to draw conclusions.

# DISCUSSION AND CONCLUSIONS

## Summary of findings

**T**he purpose of this review was to summarize the evidence base that underpins the NFSI framework. A strong evidence base to support many specific criteria of the NFSI was identified. These included the importance of having nutrition-related school policies, involving parents in school-based nutrition interventions, implementing effective nutrition and physical activity education, creating healthy school food environments and ensuring school-based monitoring of children's growth. However, meta-analyses related to other criteria (e.g. the role of training staff in nutrition and physical activity, the role of staff as role-models of healthy behaviour, the need to prevent bullying) do not yet exist.

Findings from this review suggest that comprehensive school nutrition policies (NFSI Component 1) using multiple components and approaches (e.g. diet, physical activity, educational interventions, environmental changes) are associated with positive weight-related, dietary and other outcomes among school children. The majority of the reviews considering multicomponent programmes combining diet and physical activity interventions found this combination effective in addressing weight-related outcomes. A smaller number of reviews examined combinations of approaches, e.g. nutrition improvement through curriculum, environment and parental involvement. These also found positive effects.

A large number of reviews was identified which found positive effects from enhancing awareness and capacity building of the wider school community (NFSI Component 2). The effect of engaging families and communities through community involvement and outreach in the area of nutrition and health-related issues was the most frequently studied intervention. Parental involvement was identified as a moderating factor leading to greater success, with greater impact for a higher level of parental involvement. Direct involvement methods (e.g. face-to-face) where parents are expected to take an active role were more effective than indirect methods (e.g. newsletters) where parents

may remain passive recipients of information. Less evidence was identified for the effect of staff training in delivering nutrition and healthy diet interventions, but current evidence suggests beneficial effects from training teachers and involving experts in school-based nutrition activities.

Numerous reviews examined effectiveness or different aspects of delivering nutrition and health promoting curricula (NFSI Component 3). Effective nutrition education programmes were behaviourally-focused, context and age-specific, of longer duration and intensity, facilitated by trained staff, integrated into the curricula and/or implemented in combination with other approaches (e.g. changes to the environment). Hands-on learning strategies and practical skills were considered promising, as were those that built children's self-efficacy in making healthy changes in their diet and physical activity levels. Physical activity education was more effective when combined with nutrition interventions.

A large body of evidence also exists for creating supportive environments for nutrition (NFSI Component 4), particularly through increasing availability of healthy foods and beverages and simultaneously reducing availability of unhealthy foods and beverages. Positive effects were reported on dietary and food availability outcomes from school lunch standards, competitive food and beverage policies and school food procurement




policies. Provision of school food, including fortified foods, had positive effect in low-income or disadvantaged settings. Provision of fruit and vegetables to children increased their consumption. Less evidence was identified on the impact of messaging and restricting marketing, although positive outcomes were reported in a handful of reviews of such interventions.

Some evidence was identified regarding supportive school health services for nutrition (NFSI Component 5). School-based weight monitoring and screening programmes demonstrated positive effects in both children and their families. School health service delivery of interventions such as micronutrient supplementation, deworming and nutrition counselling also had positive results and supported the use of schools as a delivery platform for essential nutrition actions to school-age children and adolescents.

## Strengths and limitations

This comprehensive review which identified more than 100 reviews synthesizing findings from primary studies systematically assesses and summarizes the evidence underpinning the NFSI criteria. The findings of this review may inform governments, policy-makers, and researchers concerned with school-based health and nutrition programmes and initiatives. As demonstrated in the Global Nutrition Policy Review conducted in 2016-2017 (12), there is a compelling need for comprehensive school health and nutrition programmes and policies, implementation of which had declined since the Global Nutrition Policy Review conducted in 2009-2010 (13).

A major limitation of the evidence base is the geographical bias towards higher-income countries. Except for 13 reviews in low- or middle-



income countries or among disadvantaged populations in high-income countries, the bulk of the evidence was from high-income countries and related to healthy diets and/or prevention of overweight/obesity. Only one of the low- or middle-income country reviews considered programmes to achieve healthy diets and prevent obesity, whereas other reviews focused on school feeding or interventions to reduce undernutrition. On the other hand, only one review among disadvantaged populations in high-income countries focused on undernutrition, while other reviews focused on healthy diets and obesity prevention.

Other limitations of this review include the high level of heterogeneity amongst studies in the reviews and a likelihood of small study bias. Study populations, interventions, controls and outcomes varied across the studies themselves and in the way that these were synthesized for the reviews. Therefore, these findings must be interpreted with caution. It is also important to point out that while a large number of reviews were identified and included, many of these relied on the same primary studies.

Regarding interventions, the NFSI is a package that includes multiple components which are likely to have synergistic effects. Therefore, there are limitations to the conclusions that can be drawn about the effects of the components individually and as a whole. No review was identified that assessed the effect of the whole set of components of NFSI on the health and nutrition outcomes of school-age children and adolescents. This review relies instead on evidence that considered one or more components from the NFSI Framework. At the same time, study and review authors may not have been reporting on exposure of the study populations to other components which had already been implemented as part of national policies and programmes. As a consequence,

this evidence review is not able to assess the synergistic effects that may result from interventions that include all components of the NFSI.

Furthermore, the commonly used categorization of “diet” and “physical activity” interventions described in the reviews may include a range of very different intervention approaches requiring different inputs, resources and engagement. Likewise, commonly studied interventions such as “nutrition education” could mask a range of different approaches (formal curricula vs. ad hoc information sessions) and have different content (food and nutrition theory vs. skills development). The methodologies and strategies used, and how they are used in combination, often determine the efficacy of such interventions. This high-level categorization may, therefore, not unpack the details that would be required in order to understand precisely what kinds of interventions and measures are needed to improve nutrition and diet in schools.

Finally, many of the outcomes associated with nutrition, such as body weight, micronutrient status, bone density and eating habits, develop over time. Unfortunately, many of the studies included in this review relied on cross-sectional data which are unable to measure these long-term effects.

### **Future research**

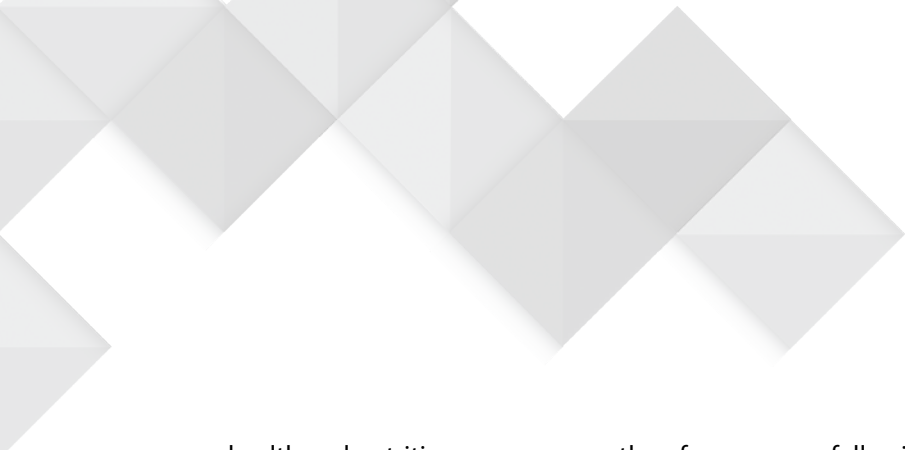
This review highlighted several areas where research was limited. These include the NFSI criteria related to dissemination of school nutrition policies, monitoring and evaluation of school nutrition-related curricula, the influence of environmental characteristics including provision of access to adequate eating places and cooking facilities, and nutrition-related school health services. Evidence was also scarce

or missing on the nutritional impact of relevant interventions that are typically not considered part of the nutrition domain. These would include interventions relating to hygiene and sanitary behaviour, separation of toilets or bullying and stigmatization. Adding nutrition outcomes to research on these interventions would provide valuable insights to underlying factors influencing nutrition.

Future work is needed to assess the impacts of the components of NFSI, both individually and *as a whole*, on the health and nutrition outcomes of school children and communities. It is well recognized that effective nutrition policy responses require a comprehensive package of interlinked, and probably synergistic, measures.

This, on the other hand, presents challenges for identifying the impact of individual interventions. It is not surprising, therefore, that the NFSI includes a broad spectrum of recommendations, and large effects on student outcomes are likely to be identified only when the full spectrum of activities are adopted and implemented. Moving forward, efforts must be made to support schools in adopting policies that cover the full NFSI set of essential criteria, whilst also ensuring robust arrangements for evaluation and monitoring, in order to build the evidence base required to identify the effectiveness of the NFSI approach or areas where it can be improved. Research on school health and nutrition interventions and the reporting of study and review results is heterogenous. To strengthen research on school





health and nutrition programmes, therefore, future research may benefit from collecting individual-level outcome measures from students at various time points, ideally over a number of years, resources permitting. Also, future reviews and individual studies should report clearly on the full set of intervention approaches applied and components addressed, aspects which were poorly documented in the reviews examined.

As noted, most of the research in this review—and in the larger area of school-health—relied on evidence from high-income countries. More research is needed from low- and lower-middle income countries, where school health and nutrition programmes may play a particularly important role, on educational outcomes as well as health and nutrition outcomes, but where contexts and resources often limit the quality of recommended intervention implementation.

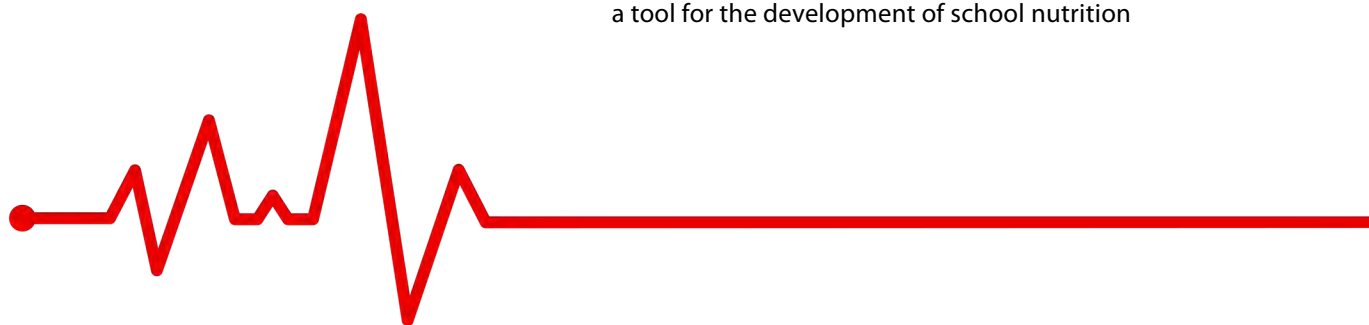
## Conclusion

Aligned with the pillars of the Health Promoting School approach, the NFSI can be well integrated into existing efforts in countries to increase the number of health promoting schools, for example through the Global School Health Initiative and the ongoing work to develop Global Standards for Health Promoting Schools. The WHO e-Library of Evidence for Nutrition Action (eLENA) (185) and WHO's recommended essential nutrition actions (186) compile guidance and recommendations relevant for school-age children and adolescents. WHO has recently initiated work to develop two sets of guidelines with relevance to the NFSI

following the WHO guideline development process. The first guideline on school food and nutrition policies is being developed by the WHO Department of Nutrition and Food Safety and its Nutrition Guidance Expert Advisory Group (NUGAG) (187, 188). The focus of the guideline is on interventions that influence the school food environment (NFSI component 4), including for example, nutrition standards or rules that determine the quality of food served or sold in and around schools and marketing restrictions of unhealthy foods and non-alcoholic beverages in and around schools. The second guideline is on school health services, being developed by the WHO Department of Maternal, Newborn, Child and Adolescent Health, which focuses on all school health services including nutrition (189).

Other supporting WHO resources and tools include the Global Nutrition Policy Review, which tracks school health and nutrition policies and programmes, as well as the Global School-based Student Health Survey, which supports Member States to measure and assess the behavioural risk factors and protective factors among children and adolescents (190). The *WHO School Policy Framework* provides additional guidance for developing and implementing school policies and programmes to promote healthy diets and increase levels of physical activity (147). This includes guidance related to starting a school policy, policy options, stakeholder involvement and monitoring and evaluation.

Several WHO regions have taken action to protect and promote good nutrition in schools. The WHO Regional Office for Europe provides a tool for the development of school nutrition



programmes (191) which outlines steps involved in designing a nutrition policy and outlines important elements of such a policy. Additionally, it provides guidance on designing children's diets, recommended nutrient intakes for children and adolescents and nutrition education. The WHO Western Pacific Regional Office developed a guide for school principals relating to restricting the sale and marketing of sugary drinks in and around schools (192). The guide outlines why a focus on school drink environments is important, as well as providing examples of success stories and recommended actions for school principals. Furthermore, all WHO Regional Offices have developed regional nutrient profile models to identify which foods and non-alcoholic beverages for which marketing to children should be restricted. In countries that do not have and are not planning to adopt related nationwide regulations — such as restrictions on print, broadcast or digital advertising and other forms of marketing — these tools could be used to develop regulations that cover marketing and availability of foods and beverages specifically in school settings.

Additional guidance may also be found from several other UN initiatives, such as the FRESH initiative, which works to raise awareness in the education sector of the value of implementing effective school health programmes as an advocacy strategy (16). FAO recently developed a framework to guide its work in the area of school food and

nutrition (193), while the UN agencies are also working jointly on guidance for setting nutrition standards for school meals.

In conclusion, this review provides an extensive summary of current evidence for the effectiveness of many components of the NFSI. Member States are encouraged, therefore, to draw on this evidence base and to use the NFSI framework to build country-specific school nutrition-related policies and programmes. In doing so, they can fully realize the potential of schools as a key setting for improving nutrition throughout childhood and adolescence, while laying good foundations for health and well-being later in life. In doing so, they can fully realize the potential of schools as a key setting for improving nutrition throughout childhood and adolescence, while laying good foundations for health and wellbeing later in life.



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# ANNEX I SUMMARY OF EXPERIENCE IN PILOTING, IMPLEMENTING AND EVALUATING THE NFSI IN COUNTRIES

**T**he NFSI framework and a self-appraisal tool (featuring 41 yes/no questions based on the five components of the NFSI) were pilot tested in 18 countries to identify the appropriateness and feasibility of the content.

In the initial pilot in 2006-2007, countries felt the NFSI was important but may need adaptation to local contexts. Concerns were raised about the practical application and implementation of the Initiative, particularly in low-resource settings. There were also challenges related to translating the documents into expressions that could be understood in various contexts, as raised by the 10 European pilot countries. Participants suggested that the questionnaire be validated and made more applicable to the specific country contexts. Some countries, such as Croatia (194), highlighted the need to integrate the NFSI into national nutrition policies. Subsequently, several European countries have indeed established national Nutrition-Friendly Schools policies and programmes, such as Turkey where more than 16 000 schools are implementing it (27, 195). Feedback was also provided by India, collected in 2007 on the basis of a pilot with four schools, indicating that schools did not have a written nutrition policy and there was no sustainable health education programming (196).

The NFSI was later pilot tested in six schools in Benin and Burkina Faso (26). The self-appraisal by nutrition committees of pilot schools indicated that no schools had a written nutrition policy, while one (private) school had an informal policy. The assessment highlighted inadequate access of children to clean water, hygienic food and toilet facilities in over half the schools. Schools did not monitor growth regularly, due to lack of equipment. As part of the project, nutrition was integrated into the curriculum, nutrition events were held in schools, gardening and poultry raising were conducted, sanitation was improved and street vendors received training to improve hygiene and the nutritional value of food sold to school children (9). An impact evaluation of the NFSI in Burkina Faso in 2014 (197) revealed reductions in thinness and anaemia since the baseline in 2009, but without changes in stunting and with increases in overweight. However, during the same period there has been significant improvement in the nutritional status of school children in Ouagadougou, and the NFSI may only have played a modest, albeit positive, role.

These pilot country experiences provided researchers with a valuable opportunity to identify best practices and challenges related to NFSI implementation within schools. For example, one important challenge related to the first component of the NFSI, “developing a school nutrition policy.” Many of the school stakeholders initially believed that policy formation was the mandate of the central government, rather than that of individual schools. However, after they started working on the additional NFSI components, they became aware of the importance of having a school nutrition policy. Other challenges related to teachers’ perceptions of their competence when teaching nutrition and the sense that

modifications to curricula, like school policies, fell under the remit of a central administration rather than individual schools. The pilot tests in Burkina Faso also provided the researchers with examples of best practice. For example, it was deemed easier to change the vending in schools working directly with and training the vendors. When such practices were adopted, the types of food available and the hygiene of food vendors improved. Another challenge that the NFSI pilot testing identified was the fact that some vendors were reluctant to make changes to the food that was available due to fears of losing business, which can be an important source of revenue for schools. Making changes related to school nutrition and health services was often stymied by a lack of resources or poor access to personnel from other sectors (such as health care). The authors concluded that the NFSI has the potential to mobilize schools and communities to work to improve nutrition and health, but activities need to be modified to specific school needs and contexts. Lack of resources at the school level (and household poverty) appear to create implementation challenges in low-income countries.

In 2014-2015, researchers at the University of Oxford and University of Colombo worked with WHO to generate an NFSI tool for researchers to assess school environments in Sri Lanka. Unlike the NFSI self-appraisal tool, which is completed by committees within schools, this tool was designed for external evaluation. It involves a researcher conducting a semi-structured interview with school principals or a senior staff member to assess school policies and practices related to the NFSI. The Oxford team's NFSI tool for researchers was used to assess school nutrition policies and practices as they changed over time, as part of a larger World Bank-funded project in rural Sri Lanka entitled Integrating Nutrition Promotion and Rural Development. Multilevel analyses while controlling for confounders at both the school- and student-levels found no significant associations between the implementation of NFSI actions in schools and nutrition-related outcomes among students (198).



# ANNEX II DETAILS OF REVIEWS INCLUDED

AUTHOR, YEAR	NFS ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Aaron, Dror and Yang, 2015 (150)	4.1	This systematic review and meta-analysis of 10 school-based studies found that MMN fortified beverages provided to school-age children improved haemoglobin and serum ferritin levels and reduced risk of anaemia, iron deficiency and iron deficiency anaemia.	The review included 10 double-blinded RCT studies published between 2003 and 2013.	MMN fortified non-dairy beverage interventions to reduce risk of anaemia and iron deficiency in school-age children.	Children (n=4094) mean age range 5–18 years in the school setting in Bangladesh, Botswana, India, Nigeria, the Philippines, South Africa and the United Republic of Tanzania.	Meta-analysis of 9 studies found that compared to iso-caloric controls, children who received MMN fortified beverages for 8 weeks to 6 months showed significant improvements in haemoglobin (+2.76 g/L; 95% CI: 1.19, 4.33; P=0.004, 8 studies) and serum ferritin (+15.42 pmol/L; 96% CI: 5.73, 25.12; P=0.007; 8 studies), and reduced risk of anaemia (RR 0.58; 95% CI: 0.29, 0.88; P=0.005; 6 studies), iron deficiency (RR: 0.34; 95% CI: 0.21, 0.55; P=0.002; 7 studies), and iron deficiency anaemia (RR: 0.17; 95% CI: 0.06, 0.53; P=0.02; 3 studies). No significant intervention effects of fortified beverages were found for serum retinol, zinc or vitamin B12. A moderate but significant effect was found for weight gain in the intervention compared with the control groups (+0.30 kg; 95% CI: 0.01, 0.58; P=0.04; 6 studies), while neither height, WAZ nor HAZ differed significantly between groups.
Abdel Rahman et al., 2018 (118)	3.1	This systematic review and meta-analysis of 16 studies, 12 of which were school-based, of the effectiveness of educational and behavioural interventions in reducing SSB intake found modest impact on SSB consumption and no effect on BMI z-score.	The review included 16 RCT studies published between 2004 and 2015.	Educational or behavioural interventions to reduce the intake of SSBs in children and adolescents. Of the 12 school-based studies, 8 used educational approaches alone (e.g. classroom lessons) and 4 combined education with environmental interventions (e.g. water fountains, provision of water bottles).	Children and adolescents aged 4–16 years in Europe, the United States and Latin America, in schools (12 studies) or home/community (4 studies).	Of the 12 school-based studies, only 2 studies (one on education alone and one on educational + environmental interventions) provided data that could be pooled into a meta-analysis which resulted in borderline significance for reduction in SSB consumption (MD: -26.53 ml/day; 95% CI: -53.72, 0.66; P=0.06) and no effect on reduction of BMI z scores. Six of the 10 remaining trials reported reductions in SSB consumption.

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Adelman, Gilligan and Lehrer, 2008 (155)	4.1	This literature review of 20 school-based studies of the impact of food for education programmes on education and nutrition outcomes found evidence of effects on food consumption and micronutrient status, provided that initial consumption and nutrient deficiencies are identified and that programmes are tailored to address these conditions.	The review included 20 studies of various design (e.g. RCTs, field trials, quasi-experimental designs) published between 1981 and 2005.	Food for education (FFE) programmes (e.g. breakfast, mid-day meal, micronutrient fortified meals/snacks, animal-source foods).	Children in primary schools in low- and middle-income countries in Africa, Asia and Latin America.	Of the 20 studies, 12 measured impact of FFE on nutrition-related outcomes. Of 4 studies measuring consumption related outcomes, 3 found that school feeding increased caloric intake among school-aged children, particularly when baseline was well below their age- or weight-recommended consumption level. Furthermore, 3 out of 4 studies found that increasing access to calories over a sufficient period increased body size or composition (e.g. height, weight, BMI, MUAC). However, provision of micronutrient rich foods or deworming seemed to have contributed to improvements in some outcomes (e.g. height, MUAC). Improvements were typically small, but the authors note that the effect may have been mitigated by increased activity levels. Iron status was improved as result of fortified school meals in 3 out of 4 studies, vitamin B12 status was improved as result of meat-based meals improved in 1 study, vitamin A was improved as result of vitamin A fortification in 1 out of 2 studies, prevalence of iodine deficiency was reduced as result of iodine fortification in 1 study.



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Afshin et al., 2015 (40)	1.1, 4.1	This review of the evidence for specific policies to improve dietary habits and reduce cardiovascular and metabolic risk factors, which included 76 studies of school procurement policies, concluded that changes in school procurement policies appear effective for either increasing healthy or reducing unhealthy choices, while setting of nutrition standards has less consistent benefits.	The review included studies of various designs evaluating the effectiveness of policy strategies to improve diet published after 1980. For school procurement policies, 76 studies of randomized or quasi-experimental studies were included.	Interventions included mass media campaigns, food and menu labelling, taxation and subsidies, local built environment, school procurement policies, worksite wellness programmes, and marketing standards. School procurement policies, including multi-component studies if these regulations were a major component of the intervention, to 1) increase in availability of healthful foods and beverages (e.g. F&V, low-fat snacks, milk, whole grain products, water), 2) implement standards on availability of unhealthy foods and beverages (e.g. restrictions or bans, nutrient standards for competitive foods in cafeterias, vending machines, school stores, snack bars, or snack trucks - about half of these were local programmes; others were based on city, state, or national policies), and/ or 3) implement nutrition standards for school meals (based on e.g. food, nutrients, portion size).	All population groups worldwide. School-based studies largely covered children in schools in Europe and in North America.	Among 31 studies to increase in availability of healthy foods and beverages, interventions that aimed to increase F&V intake appeared effective. Among 26 studies of the effect of restricting unhealthy foods and beverages in schools, interventions appeared generally effective in reducing intake of unhealthy competitive foods and beverages and decreasing incidence and prevalence of overweight/obesity, with governmental and school policies being more effective than voluntary programmes. Among 22 studies of the effect of standards for school meals for lunch and/or breakfast, results were inconsistent across studies and no consistent patterns were identified to explain the heterogeneous findings. The authors concluded that changes in school procurement policies appear effective for either increasing healthy or reducing unhealthy choices, while setting of nutrition standards have less consistent benefits.

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Aje and Chapman-Novakofski, 2014 (126)	3.1	This systematic review of 15 studies of computer-based nutrition education interventions, 10 of which were school-based, concluded that such programmes may have potential to improve dietary habits among adolescents.	The review included 15 studies including RCTs, quasi-experimental trials and RCTs, published between 2003 and 2013.	Computer-based education or behavioural interventions via a stationary or laptop computer targeting disordered eating behaviours including overeating and binge eating, healthy eating and lifestyle behaviours, F&V consumption, SSB consumption or fat intake	Adolescents aged 12–18 years in the United States and Europe; 10 of the 15 studies were in the school setting.	Most studies conducted in the school setting found significant results in at least one of the dietary or anthropometric outcome measures post-intervention, albeit some only among at-risk subgroups or among girls. The authors concluded that computer-based nutrition education programmes have the potential to persuade adolescents to improve overall dietary habits and curb the expansion of overweight and obesity.
Al-Khudairy et al., 2017 (64)	1.1	This Cochrane review and meta-analysis of 44 obesity treatment studies, 7 of which were school-based, found low quality evidence that diet, PA and behavioural interventions reduce measures of BMI and found moderate quality evidence that they reduce weight in overweight or obese adolescents. There was no difference observed in subgroup analyses by setting.	The review included 44 RCTs, published between 1968 and 2015.	Diet, PA and/or behaviour change interventions (e.g. education, counselling, healthy food choices, environmental control) for treating overweight or obesity in adolescents. Five of 7 studies with a PA component in the school setting also included a dietary component.	Overweight or obese adolescents aged 12–17.5 years (n=4781) in multiple settings (7 out of 44 studies were conducted in the school setting) worldwide, with most included studies from the United States and Europe.	The pooled results of all subgroups showed that behaviour change intervention programmes gave significant reductions in BMI (MD: -1.18 kg/m <sup>2</sup> ; 95% CI: -1.67, -0.69; 2774 participants; 28 trials), BMI z-score (MD: -0.13; 95% CI: -0.21, -0.05; 2399 participants; 20 trials) and weight change (MD: -3.67kg; 95% CI: -5.21, -2.13; 1993 participants; 20 trials). Subgroup analyses gave no differences in BMI and BMI z-score between the different settings. In the school-based studies, the effects were positive but not significant for both BMI (-0.91 kg/m <sup>2</sup> ; 95% CI: -1.97, 0.15; 613 participants; 7 trials) and BMI z-score (-0.7 kg/m <sup>2</sup> ; 95% CI: -2.06, 0.66; 150 participants; 2 trials).

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Aloia et al., 2016 (78)	1.1, 2.2, 3.1	This systematic review of school-based interventions targeting F&V consumption in the US were successful in 8 of 14 studies, with the most promising components being food service staff involvement and nutrition education.	The review included 14 controlled trials (5 randomized and 9 non-randomized) published between 2006 and 2014.	School-based interventions to increase F&V consumption including parental involvement, teacher involvement, nutrition education, food service and school gardens. Most interventions were part of a multicomponent programme while one was single component (i.e. interactive books).	Children in kindergarten through 8th grade in the United States.	Overall, 8 out of 14 studies (13 of which were multicomponent) showed significant increases in consumption of F&V among school children. The most promising intervention component was food service staff involvement and nutrition education, whereas teacher involvement, parent involvement or gardens were not associated with positive findings. Likewise, intervention duration, type of theory used, style of intervention leadership or aims to affect antecedents of F&V consumption were not correlated with higher consumption.
Avery, Bostock and McCullough, 2015 (134)	3.1	This systematic review of 8 studies, 7 of which were school-based, suggested that school-based education programmes focusing on reducing SSB consumption and including follow-up modules offer opportunities for implementing effective, sustainable interventions.	The review included 8 RCTs published between 2004 and 2013.	Interventions to reduce SSB consumption (e.g. school-based educational programmes, school-based educational programme combined with environmental change, school-distributed drinks and home-delivered drinks).	Children aged 8–15 years in Europe, Brazil and the United States.	Six studies achieved significant ( $P < 0.05$ ) reductions in SSB intake, although this was not always sustained. Four studies focusing on educational approaches reduced the risk of being overweight, though one of these also provided a replacement drink. The authors concluded that school-based education programmes to reduce SSB consumption that include follow-up modules offer opportunities for implementing effective, sustainable interventions. Peer support and changing the school environment (e.g. providing water or replacement drinks) to support educational programmes could improve their effectiveness.

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Bailey, Drummond and Ward, 2019 (122)	3-1, 3-3	This systematic literature review of 44 school-based studies found that food literacy in adolescents improves dietary intake, and that hands-on cooking skills and use of chefs or school gardens were beneficial.	The review included 44 studies, 37 of which were quantitative studies (16 cross-sectional, 13 quasi-experimental, 1 pre- and post-test design, 1 RCT, 1 longitudinal cohort study, 1 observational, 4 mixed methods) and 7 qualitative studies, published between 1990 and 2017.	Interventions to increase food literacy among adolescents in secondary schools, including practical cooking classes, reading nutritional labels, school-based gardens, school supplementary food programmes, technology intervention), lectures about nutritional education and food safety. Duration ranged from 1 week to 10 years.	Adolescents aged 10–19 years in secondary schools, mostly in Australia, Europe and the United States, but also in Canada, China, Iran, South Africa, India and Kenya.	Adolescents with greater nutritional knowledge and food skills showed healthier dietary practices. Out of 9 studies measuring effect on knowledge, 8 showed a positive impact on dietary intake. However, there was a mixed association between food literacy and long-term healthy dietary behaviour. Of programmatic interventions, 4 out of 5 studies on school-based gardening showed a positive impact on F&V consumption. The 4 studies that utilized experimental cooking and nutritional education programmes led by chef instructors showed positive results in overall cooking confidence, cooking skills and tasting new foods. The qualitative studies found that adolescents and home economics teachers value food literacy skills, but the school food environments are seldom comprehensively supportive of food literacy.

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Best et al., 2011 (157)	4.1	This systematic review of 12 school-based studies showed a positive effect of providing MMN fortified foods to children on micronutrient status, but evidence for the effects on growth, morbidity and cognition were inconsistent.	The review included 12 studies (5 RCTs, 6 quasi-experimental controlled clinical trials, and 1 CBA). Studies were conducted in 1999 or later.	Provision of MMN fortified foods, using carriers such as beverages (6 studies), milk products (2 studies), biscuits (2 studies), or seasoning powder/salt (2 studies) fortified with a combination of at least iron and vitamin A or beta carotene and often iodine, zinc, B-vitamins and/ or vitamin C. Fortified foods usually provided between 50 and 100% of RDA for these micronutrients. 11 studies compared provision of MMN fortified food to unfortified food, and 1 study compared MMN fortified food to single-micronutrient fortified food.	Children aged 6–18 years, primarily in the school setting (11 of 12 studies), mostly in low- and middle-income countries among children with poor nutritional status (Bangladesh, Botswana, India, Indonesia, Philippines, Morocco, South Africa, Thailand, United Republic of Tanzania, Viet Nam). One study was conducted in a HLC among children with good nutritional status (Australia).	MMN fortification of foods (with the exception of zinc) consistently led to improvement of short-term micronutrient status with significantly improved micronutrient status in 10 of 11 intervention group. The impacts of MMN fortification on functional health outcomes (growth, morbidity, cognitive development) were inconsistent. Out of 7 studies measuring anthropometric outcomes, 4 studies reported a significant beneficial effect on weight gain, increased BMI or MUAC, but only 2 showed an effect on height. 4 of 7 studies showed some beneficial effects on children's health, including reduced incidence or duration of diarrhoea and respiratory diseases. 2 out of 3 studies measuring impact on diarrhoea showed significant improvement, but only 1 out of 3 measuring impact on respiratory related diseases showed significant improvement. Impacts on cognitive performance were inconsistent and varied between cognitive domains. However, there were consistent positive results on working memory across studies, with 4 of 6 studies reporting some beneficial effect. The authors conclude that fortified school meals can provide a safe and effective nutritional intervention and make a valuable contribution to the nutritional needs of school children.

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Black, Matvienko-Sikar and Kearney, 2017 (105)	2.2, 4.2, 4.11	This systematic review of 39 school-based diet and PA interventions found insufficient evidence to determine the impact of parent involvement in these interventions.	The review included 39 studies, all of which were RCTs. The dates of publication ranged from 1996 to 2014, with a majority published in the last 10 years.	Most interventions were multiple component nutrition programmes that included combinations of class curriculum activities, school food service modifications, home activities, enhanced PE/PA and strategies to engage parents/families. There were also 4 studies of school meal programmes, 1 school gardening study, 1 school fruit programme study and 2 school canteen studies.	The majority of the studies (82%) were undertaken in schools (25 studies) or preschools (6 studies) in the United States, Europe, Australia and New Zealand. The participants in the primary school-based programmes were predominantly aged 8–12 years.	There were substantial and statistically significant improvements in dietary intake in only 31% of outcomes assessed—all related to increased F&V or decreased fat intake. In preschool/school-based studies, 7 out of 13 studies with a parent involvement component vs 4 out of 7 studies with no such component reported increased F&V intake, especially fruit, whereas 4 out of 8 studies with a parent involvement component vs 1 out of 3 studies with no such component reported decreased fat intake. This led the authors to conclude that overall there was insufficient evidence to determine the impact of involving parents in school/preschool nutrition programmes. The authors also noted that the most effective school-based programmes had incorporated role-models including peers, teachers and heroic figures, rewards, and increased access to healthy foods.
Bleich et al., 2018 (80)	1.1, 2.2	This systematic review of 56 studies in various settings, of which 47 were conducted in schools, preschools or after school, found most support for effectiveness of school-based interventions that combined diet and PA and included a secondary home setting.	The review included 56 studies, RCTs and quasi-experimental studies or natural experiments with a control group, published between 2013 and 2017.	Interventions designed to prevent or manage weight gain through diet and/or PA (e.g. educational, environmental, parental involvement).	Children and adolescents (aged 2–19 years) in 56 studies in multiple settings including schools or after school (41 studies) and preschools (6 studies) in the Americas, Europe, China, India, Republic of Korea and Australia	Of 24 school-based RCT studies, 17 showed significant improvement for at least one adiposity-related outcome (BMI, BMI z-score, BMI percentile, body fat percentage, skinfold thickness, waist circumference, or prevalence of overweight or obesity). All of the school-based RCTs that reported positive results included a secondary home setting and used combined diet and PA interventions, including intervention elements such as enhanced or lengthened PA time, implementation of a nutrition education curriculum, and improvement in participants' self-regulation and efficacy.

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Bramante et al., 2019 (35)	1.1, 4.1, 4.2	This systematic review of 33 natural experiments for childhood obesity prevention and control, 24 of which were school-based, found that school-based policies focusing on both the food and beverage and PA environments (versus targeting only one) consistently showed improvements in BMI.	The review included 33 natural experiment studies, published between 2009 and 2017.	Of 24 school-based studies, 14 focused on the food/beverage environment, 6 on the PA/built environment and 4 on multiple environments. Among the 29 studies conducted in the United States, 35% evaluated local policies, 31% state/regional policies (e.g. competitive food laws and school-district food policies), 24% federal-level policies (e.g. Child Nutrition and Special Supplemental Nutrition Program for Women, Infants, and Children Reauthorization Act), and 10% non-governmental policies.	Children in the United States (29 studies), Canada (2 studies) and Australia (2 studies); 73% of studies were conducted in the school setting (24 studies) across several grade levels (1 included child care setting, 12 studies included elementary school, 13 included middle school, and 11 included high school).	Eight of 14 school-based studies that focused on the food and beverage environment achieved favourable BMI outcomes. All 4 studies that took place in a school setting and focused on both the food/beverage and PA/built environments, had favourable BMI outcomes. Two of these studies that also focused on healthy messaging achieved the largest improvement in BMI. Furthermore, 3 of 4 school-based studies that focused on the food and beverage environment showed reduced SSB consumption. These 3 studies evaluated state- or school-wide policies to decrease access to SSBs. One of 3 school-based studies that focused on the food and beverage environment showed increased F&V consumption as result of implementing a competitive food policy. Additionally, the effectiveness on BMI was assessed by the level of government policy. Among the 26 studies in the United States evaluating government policies, 15 (58%) reported favourable effects on BMI — 6 of 7 (85%) federal policies, 3 of 9 (33%) state/regional policies, and 6 of 10 (60%) local policies.

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Brown and Summerbell, 2009 (87)	1.1, 3.2	This systematic review of 38 school-based obesity prevention studies found insufficient evidence on the effectiveness of dietary interventions alone, and inconsistent evidence for PA interventions alone or combined interventions, though they may help prevent obesity and overweight in the long term.	The review included 38 studies which were either RCTs or controlled clinical trials published between 1993 and 2007.	Of the 38 studies included, 3 included diet interventions only (nutrition education, school breakfast, change in school lunches), 15 included PA interventions only, and 20 included both diet and PA interventions.	Children and adolescents aged 4–18 years largely in primary schools (23 studies) and secondary schools (12 studies) but also in kindergarten or preschool (2 studies) and high school (1 study) worldwide with a majority of studies conducted in the United States and Europe.	One of 3 (33%) diet studies, 5 of 15 (33%) PA studies and 9 of 20 (45%) combined diet and PA studies demonstrated significant differences between intervention and control for BMI. The review found insufficient evidence to draw conclusions about the effectiveness of dietary interventions or to compare their efficacy to PA interventions. They suggest that dietary interventions (such as providing breakfast in schools) may help prevent pupils from becoming overweight in the short term. Although inconsistent, there is some suggestion that PA interventions may help pupils maintain a healthy weight in the short term, particularly among younger children and girls. In studies with combined interventions, the findings are also inconsistent, but the authors suggest that combined diet and PA interventions may help to prevent children from becoming overweight in the long term.
Brown et al., 2016 (73)	1.1	This systematic review of 17 school-based childhood obesity prevention studies found that multifaceted programmes were more likely to improve BMI outcomes.	The review included 17 studies (RCTs and non-randomized controlled trials with no-intervention controls) published between 2007 and 2014.	Most studies used a combination of environmental, educational, PA and parental involvement strategies, while four used only educational strategies.	School-based studies in primary school-aged children in Europe, Canada, Chile, New Zealand and the United States.	Programmes lasting between 6–12 months that involve multiple environmental, educational and physical strategies appear to be most likely to result in BMI or BMI z-score improvement. Six out of 14 studies reported improvements in BMI for the total intervention group, whereas 9 of the 14 studies reported improvements in at least one subgroup (e.g. girls, older children).



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Brown et al., 2019 (57)	1.1.3.2	This Cochrane systematic review and meta-analysis of 153 obesity prevention studies, of which 113 were school-based, found significant effects on BMI and BMI z-score from combined diet/PA and PA alone in children 6–12 years and of PA alone in children 13–18 years in the school setting, but no effect on children 0–5 years in the preschool or child care setting.	The review included 153 studies (108 cluster-RCTs and 45 RCTs) published between 1993 and 2016.	Studies included a combination of diet and PA interventions (93 studies), PA alone (39 studies) and diet alone (21 studies). The interventions used various approaches (e.g. educational, environmental, policy, parent involvement).	Children aged 0–18 years in multiple settings (91 studies in primary or secondary school and 22 in preschool) mostly from HIC (139 studies) as well as upper- (13 studies) and lower middle-income countries (1 study).	In the meta-analysis of studies in children 0–5 years in childcare or preschool, no significant effects were reported for combined diet and PA or for PA alone. In children 6–12 years in the school setting, significant effect was found on BMI z-score from combined diet and PA interventions (-0.04; 95%CI: -0.08, -0.01; 15 studies with 23 252 participants) and on BMI from PA alone (-0.10 kg/m <sup>2</sup> ; 95%CI: -0.14, -0.06; 12 studies with 15 929 participants), with no significant effect from diet alone interventions. In children 13–18 years, significant effect was found on BMI z-score from PA alone (-0.70; 95%CI: -0.30, -0.10; 1 study with 100 participants) and on BMI (-1.53 kg/m <sup>2</sup> ; 95%CI: -2.67, -0.39; 4 studies with 720 participants), with no significant effect from diet alone or diet and PA combined. They also pooled results from studies that compared different interventions against each other (e.g. diet alone vs combined diet/PA) and all such analyses did not find differences in impact.
Cai et al 2014 (61)	1.1.3.2	This systematic review and meta-analysis of 28 studies, 23 of which in the school setting, showed a moderate but significant improvement on blood pressure from child obesity prevention programmes, with combined diet and PA interventions being the most effective.	The review included 23 studies assessing 28 interventions (RCTs, quasi-experimental studies and natural experiments), published between 1985 and 2012.	Obesity prevention interventions. School-based interventions were of a duration of minimum 6 months and utilized various approaches, largely educational but also affecting the environment, food service, or involving parents. Twenty-three of the 28 interventions involved a school setting, 18 used a combination of diet and PA interventions, 8 applied a PA-only intervention and 2 used a diet-only intervention.	Children (n=18 925) with mean baseline age range 6.0–13.9 years, largely in the school setting in the United States, Europe, Australia and Canada.	The meta-analysis found moderate but significant average reductions in the weighted mean difference (WMD) in blood pressure, in both SBP (WMD: -1.64 mmHg; 95% CI: -2.56, -0.71; P=0.001; 19 studies) and DBP (WMD: -1.44 mmHg; 95% CI: -2.28, -0.60; P=0.001; 18 studies). In the subgroup analyses, significant results were seen for the combined diet and PA interventions in both SBP (WMD: -2.11 mmHg; 95%CI: -3.19, -1.03) and DBP (WMD: -1.51 mmHg; 95%CI: -2.55, -0.47) but not for the interventions with PA alone.

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Cai et al 2014 (62)	1.1, 3.2	This systematic review and meta-analysis of 20 interventions, 19 of which were school-based, showed that childhood obesity prevention programmes significantly improved LDL-C and HDL-C, with combined diet and PA interventions being the most effective.	The review included 17 studies (RCTs, quasi-experimental studies and natural experiments) of 20 interventions published between 1985 and 2012.	The 17 studies assessed 20 interventions (some studies had more than one intervention group). School-based intervention needed to have a duration of minimum 6 months and utilized various approaches, largely educational but also affecting the environment or involving parents. Nineteen of the 20 interventions involved a school setting, 10 used a combination of diet and PA interventions, 8 applied a PA-only intervention and 2 used a diet-only intervention.	Children (n=13 136) with mean baseline age range 6.0–13.9 years, largely in the school setting in the United States, Europe, Australia and Canada.	The meta-analysis found a significant desirable effect on the weighted mean difference (WMD) of LDL-C (WMD: -6.06 mg/dl; 95% CI: -11.09, -1.02; P=0.018) and HDL-C (WMD: 1.87 mg/dl; 95% CI: 0.39, 3.34; P=0.013) and non-significant reductions in total cholesterol and triglyceride. In the subgroup analyses of different intervention types, significant results were found for LDL-C from diet and PA (WMD: -8.49 mg/dl; 95% CI: -12.77, -4.21), diet only (WMD: -17.59 mg/dl; 95% CI: -25.58, -9.60) and PA only (WMD: -2.67 mg/dl; 95% CI: -4.30, -1.03) interventions and on total cholesterol from diet-only interventions (WMD: -17.21 mg/dl; 95% CI: -25.76, -8.66).
Calvert, Dempsey and Povey, 2019 (731)	3.1, 4.1	This systematic review of 29 school-based healthy eating intervention studies in adolescents found the most effective intervention components to be peer involvement, use of educational media, enhanced availability of healthy foods, and tailored computer-based feedback.	The review included 29 studies (9 RCTs, 7 quasi-experimental design, 3 cohort studies) published between 1987 and 2017.	Interventions included healthy eating lessons (20 studies), healthy eating activities such as practical activities or role-playing (13 studies), problem solving worksheets (16 studies) and/or a practical lesson (11 studies), peer involvement (9 studies) and parental involvement (10 studies).	Adolescents aged 11–16 years in the school setting, largely in the United States and Europe, as well as in Australia, Canada, China, Israel and Tunisia.	Overall, 24 of the 29 studies were successful in promoting dietary behaviour change. The authors concluded that the interventions appeared more effective in this age group when they involved peers (9 of 9 studies with this component were successful), used educational media to deliver health messages (7 of 7 studies with this component were successful), increased availability of healthy foods in school (6 of 6 studies with this component), and incorporated computer-based individualized feedback with normative information on eating behaviours (4 of 5 studies with this component were successful).

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Chiriqui, Pickel and Story, 2014 (41)	1.1, 4.1	This systematic review of 24 studies on state and district competitive food and beverage laws and policies found positive outcomes for policies focused on in-school availability and consumption, but mixed results for health outcomes (BMI, obesity and overweight).	This review included 24 natural experiments of real laws or policies published between 2006 and 2012. Study designs were cross-sectional (20 studies), longitudinal (3 studies) or a combination (1 study).	Interventions studied focused on competitive food and/or beverage state laws (14 studies), district policies (8 studies) or both (2 studies) (e.g. nutrition standards for school meals, switching from whole to 1% or non-fat milk, banning SSBs, prohibitions on the use of food as a reward). Eighteen studies focused on food and beverage policies, 4 focused on beverage-only policies, and 2 on food-only policies.	Children and adolescents in elementary, middle and high school in the United States, in the school setting.	Fifteen of the 24 food and beverage law or policy interventions influenced outcomes in the expected direction. The remaining 9 studies reported mixed or nonsignificant results, but 3 of these represented early policies from 2002 and 2004 in one state only. Of 4 studies measuring BMI or obesity, 2 studies had expected results and 2 studies had mixed results. Of 11 studies measuring consumption, purchasing or dietary intake, 6 studies had expected results, 4 had mixed results and 1 had non-significant results. Of 13 studies measuring availability and access, 11 had expected results and 2 had mixed results.
Colley et al., 2019 (76)	1.1, 4.1	This systematic review of 9 school food programmes in Canada found that multicomponent interventions were positively associated with children's development of nutrition knowledge, dietary behaviour changes and intake of healthy foods.	The review included studies of 9 school food programmes, published in 11 papers between 2005 and 2015.	All studies included school food provision, usually in combination with multiple other interventions such as policy, education, family and community involvement, 8 of which were multicomponent combining school food with healthy eating policies (5 studies), active or passive nutrition education (8 studies), and/or nutrition in the school curriculum (5 studies).	Children in primary schools in various regions in Canada, including indigenous communities; programmes often targeted disadvantaged children.	The multicomponent school food programme interventions were positively associated with children's development of nutrition knowledge in 4 out of 6 studies which measured it, in dietary behaviour and food preferences in all 7 studies measuring these, and in intake of healthy foods in 6 out of 8 studies which assessed intakes.

AUTHOR, YEAR	NFS ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
De Bourdeaudhuij et al., 2011 (68)	1.1, 3.1	This systematic review of school-based obesity prevention interventions suggests that interventions focused on education alone have less of an effect on obesity prevention than multicomponent programmes.	The review included 11 studies reported in 27 articles of various study designs (observational, experimental, extrapolated and experience-based sources) published between 1991 and 2007.	Interventions aimed at prevention of obesity and obesity-related diseases, targeting dietary and PA behaviour through education by teachers or health professionals alone in 5 studies (e.g. classroom lessons, board game) or a combination of such education and environmental measures in 6 studies (e.g. classroom lessons, modifying school meals and tuck shops, increasing PE hours or active lesson time, providing playground equipment and activity, parent or community meetings)	Primary school children aged 6–12 years (6 studies) and adolescents aged 13–18 years (5 studies) in Europe, in the school-setting.	In primary school children, multicomponent interventions showed more favourable results on various outcomes (anthropometry, knowledge, behaviour) than those only using education. However, only 1 of 4 multicomponent studies showed an effect on anthropometry. In adolescents, 2 multicomponent programmes had positive effect on anthropometric obesity measures. The authors suggest that interventions with an education component alone have less of an effect on obesity prevention than multicomponent programmes combining education with environmental interventions such as PA and the food environment.
de Sa and Lock, 2008 (77)	1.1, 4.1	This systematic review of 30 studies of school-based interventions to promote F&V consumption concluded that such interventions can increase both intake and knowledge, as 70% of studies increased F&V intake.	The review included 30 studies reported in 34 articles published between 1998 and 2007. The studies included 18 RTCs and 12 non-randomized controlled trials, all with a follow-up time beyond 3 months.	School-based interventions encouraging F&V consumption (free or subsidised F&V, classroom activities, school-wide interventions and school policy, teacher/peer leader/parent/community involvement and/or modification to the school food service); Twenty-three studies had multiple components.	Children and adolescents aged 5–18 years, parents, and other community members in the United States, Europe and New Zealand in the school setting.	School-based interventions encouraging F&V consumption were found to be effective at increasing both intake and knowledge. Twenty-two of the 30 studies (>70%) increased F&V intake (from +0.14 servings per day to +0.99 servings per day), with none decreasing intake. Five out of 7 studies reported statistically significant results on nutrition knowledge or preference, whereas 1 of 7 studies had positive impact on F&V intake and weight-related outcomes. Two of the national programmes providing free or subsidized F&V had been evaluated and showed significant increase during the scheme, with one of them also showing sustained increases after the scheme finished.

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Delgado-Noguera et al., 2011 (116)	3.1, 4.1	This systematic review and meta-analysis of 19 studies on primary school interventions to promote F&V consumption concluded that computer-based interventions were effective in increasing F&V consumption whereas multicomponent interventions and free or subsidized F&V interventions were not effective.	The review includes 19 studies (13 RCTs and 6 controlled clinical trials) published between 1998 and 2009.	Interventions to promote F&V consumption through multicomponent interventions: school educational/curriculum components, school environment modification, teacher or parent involvement (11 studies), free/subsidized F&V (3 studies) and board games or computer-based interventions (3 studies) compared against control with no intervention. Two studies involved other comparisons (free F&V distribution vs multicomponent programme and teacher led vs nutritionist led intervention).	Children aged 5–12 years in primary schools in the United States, Europe and New Zealand.	Pooled results of 2 RCTs of computer-based interventions in 606 primary school children showed effectiveness in improving consumption of F&V (SMD: 0.33; 95% CI: 0.16, 0.50; P=0.0001). No significant differences were found in pooled analysis of 7 RCTs of multicomponent interventions (n=4800) or pooling results of 2 RCTs evaluating free or subsidized F&V interventions (n=1536). The authors conclude that computer-based interventions could be considered in schools, given that they are effective and cheaper than other alternatives.
De-Regil, Jefferts and Peña-Rosas, 2017 (149)	4.1	This Cochrane review and meta-analysis of 13 studies of point-of-use fortification of foods with iron-containing MNPs, 8 of which were conducted in schools, found reduced anaemia and iron deficiency in preschool- and school-age children.	The review included 13 studies (5 RCTs, 6 randomized cluster trials, 2 pre- and post-test design).	Iron-containing MNPs for point-of-use fortification of foods.	Children aged 2–12 (n=5810) in Latin America, Africa and Asia. Eight of the 13 studies took place in a school setting.	Compared to no intervention or placebo, children receiving iron-containing MNP for point-of-use fortification of foods had lower risk of anaemia (prevalence ratio (PR): 0.66; 95% CI: 0.49, 0.88; 10 trials, 2448 children; moderate-quality evidence) and iron deficiency (PR: 0.35; 95% CI: 0.27, 0.47; 5 trials; 1364 children; moderate-quality evidence) as well as higher haemoglobin (MD: 3.37 g/L; 95% CI: 0.94, 5.80; 11 trials; 2746 children; low-quality evidence). Only one trial with 115 children reported on all-cause mortality (zero cases; low-quality evidence). There was no effect on diarrhoea (RR: 0.97; 95% CI: 0.53, 1.78; 2 trials; 366 children; low-quality evidence). The authors conclude that point-of-use fortification of foods with iron-containing MNPs reduces anaemia and iron deficiency in preschool- and school-age children, but information on mortality, morbidity, developmental outcomes and adverse effects is limited.

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
do Amaral e Melo et al., 2017 (129)	3.1	This systematic review of 11 nutrition interventions using information and communication technology could not determine the most effective type of intervention due to heterogeneity of studies but suggests that long-term interventions with frequent exposure to technological resources and aimed at a single health behaviour change may improve nutrition behaviours.	The review included 11 studies (2 RCTs, 5 cluster RCTs, 4 quasi-experimental) published between 2007 and 2015.	Nutritional interventions using information and communication technologies (computer games and programs, text messages and interactive CD-ROMs)	Adolescents aged 9–17 years in the school setting in HIC.	Five of 11 studies had positive effects on diverse dietary outcomes (e.g. increased intake of F&V, brown bread and/or decreased intake of SSBs, junk food) that were statistically different from baseline or comparison group. Targeting healthy eating associated with PA seems to be have a greater impact in adolescents' health, especially on weight. Half of the studies which combined diet and PA presented positive outcomes in both variables. All interventions using games were effective; this can be attributed to the entertaining way in which these interventions promote educative learning. Heterogeneity of the studies makes it hard to state what type of intervention is more effective; however, the authors suggest that long-term interventions with frequent exposure to technological resources that also have a theoretical component aimed at a single health behaviour change can potentially improve nutrition behaviours.

NFSI ESSENTIAL CRITERIA		STUDY SETTING AND POPULATION			RESULTS OF REVIEW	
AUTHOR, YEAR	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	POPULATION	RESULTS OF REVIEW	
Doak et al. 2006 (83)	1.1.2.2, 3.2 This systematic review of 25 largely school-based obesity prevention studies focusing on diet and PA found that a majority of studies were effective in improving outcomes related to height, weight or skinfolds; however, non-effective interventions more often included components such as family or parent involvement.	The review included 25 studies of various designs (RCTs, controlled trials, small-scale controlled trials, historical controlled trials, quasi-experimental designs) published between 1977 and 2003. One study was unpublished.	Obesity prevention interventions targeting diet and/or PA (e.g. education, counselling, curriculum, food service), sometimes supplemented by additional components (e.g. family or community involvement, extracurricular activity).	Children aged 4–16 years, largely in the school setting, largely in the United States and Europe but also in Australia and Russia.	The authors compared features of 17 interventions effective in improving outcomes related to height, weight and/or skinfolds versus 8 non-effective interventions and compared these against criteria for evaluating childhood obesity interventions, drawing on existing models for causal pathways to the condition of obesity risk in children. They found that a slightly smaller proportion of the effective interventions vs. the non-effective interventions intervened on both diet and activity (82% of studies vs. 88% of studies), included activities outside school as part of the intervention (67% vs. 88%), targeted the physical environment (24% vs. 25%), required active participation of children (82% vs. 100%) and actively involved parents (47% vs. 57%) or the broader community (6% vs. 14%), and had a mean longer duration (133 weeks vs. 61 weeks). However, most of these differences are small and none of these comparisons are statistically significant. On the other hand, the effective interventions more often intervened on television viewing (20% vs. 0) and put in place as structure that could be continued (e.g. intervention accepted by school community, financially sustainable) (94% vs. 88%).	
Driessen et al., 2014 (38)	1.1.4.1 This systematic review of school food environment policies and interventions found that most studies reported favourable outcomes, particularly for consumption or availability of healthy foods and beverages, but reported less conclusive results on BMI.	The review included 18 studies published between 2001 and 2013. Most studies were natural experiments, reporting on effects of state or national policy.	Changes to the school food environment included changes in food or beverage availability in canteens, snack bars and vending machines. The changes were implemented with or without a policy directive, and 11 of the studies were natural experiments of the effect of state or national policy changes that impacted the school food environment.	Children aged 5–18 years in primary and secondary school setting in the United Kingdom and United States.	The review considered outcomes related to body weight, food or beverage consumption and purchasing. Overall, 17 of the 18 studies reported a statistically significant increase in healthy eating behaviours and/or decrease in BMI of children. Of the 16 studies measuring purchasing behaviour or dietary outcomes, 15 reported a significant intervention effect (8 of 9 policy studies, 7 of 7 scientific studies). Two of 4 studies (all on policy) measuring BMI reported significant impact. The authors conclude that high-level policy changes impacting the school food environment are possible, have potential as obesity reduction strategies, and can reach many children.	

NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
AUTHOR, YEAR Dudley, Cotton and Peralta, 2015 (92) 2.2, 3.1, 4.2	This systematic review and meta-analysis of 49 studies found that most of the teaching strategies led to positive changes in healthy eating behaviours in primary school children, especially enhanced curricula, cross-curricula and experiential learning approaches.	The review included 49 studies (1 RCT, 13 quasi-experimental studies, and 35 cluster-controlled trials) published between 1974 and 2011.	Teaching strategy interventions included: 1) Enhanced curriculum approaches (i.e. speciality nutrition education programmes beyond existing health curricula) (29 studies); 2) cross-curricular approaches (i.e. nutrition education programmes delivered across two or more traditional school subjects) (11 studies); 3) parental involvement (10 studies); 4) experiential learning approaches (e.g. school garden, cooking demos) (10 studies); 5) contingent reinforcement approaches (i.e. rewards or incentives given to students in response to desired behaviours) (7 studies); 6) literary abstraction approaches (i.e. literature read by/to children whereby a character promotes/exemplifies positive behaviours) (3 studies); 7) games-based approaches (2 studies); and 8) web-based approaches (2 studies).	Children aged 5–12 years (n=38 001) in primary school settings, primarily in the United States and Europe, but also Canada, Australia, New Zealand, and Trinidad and Tobago.	Most of the teaching strategies led to positive changes in eating behaviours, but in the pooling of results from studies involving 20 234 children, fewer strategies had mean effect sizes $Md > 0.4$ , which was considered as the cut-off for good investments in this review according to 'Hattie's Zone of Desired Effects' observed in education studies. Curriculum-based approaches were most popular, but only considered good investments in subsequent meta-analyses when implemented alongside other teaching strategies ( $Md = 0.12$ for food consumption/energy intake, $Md = 0.45$ for F&V consumption). Enhanced curriculum approaches were effective at increasing knowledge ( $Md = 0.75$ ) but not at reducing sugar intake from beverages with added sugar or fruit juices ( $Md = 0.28$ ). Cross-curricular approaches were effective to improve F&V consumption ( $Md = 0.63$ ) as well as sugar intake from beverages ( $Md = 0.42$ ), whereas contingent reinforcement approaches were effective to increase F&V consumption ( $Md = 1.34$ ) but this was based on only 2 studies. Experiential learning strategies were associated with the largest pooled mean effect sizes for all 3 outcome areas ( $Md = 1.31$ for food consumption/energy intake, $Md = 0.68$ for F&V consumption, $Md = 1.35$ preference and increased nutritional knowledge outcomes). Reducing sugar consumption and preference were most influenced by cross-curricular approaches embedded in interventions. Parental involvement also generally led to good results in individual studies (91% positive outcomes), although the pooled mean effect size ( $Md = 0.39$ ) was just below the cut-off.



NFSI ESSENTIAL CRITERIA		STUDY SETTING AND POPULATION			RESULTS OF REVIEW	
AUTHOR, YEAR	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	POPULATION	RESULTS OF REVIEW	
Ejemot-Nwadiaro et al., 2015 (174)	4.7 This systematic review and meta-analysis of 22 studies, 12 of which were conducted in schools or child day-care centres, found that hand washing promotion may reduce diarrhoea episodes in child day-care centres and schools by about 30% and perhaps by similar rates in lower income countries.	The review included 22 RCTs published between 1997 and 2013.	Hand washing promotion (education activities, with or without provision of soap).	Twelve of the 22 studies were conducted in child day-care centres or schools in mainly HIC involving children aged under 3 years and up to 10 years (n=54 006). Other studies were conducted in community settings or hospitals in low- and middle-income countries.	Hand washing promotion at child day-care facilities or schools prevents around about 30% of diarrhoea episodes in HIC (RR: 0.70; 95% CI 0.58, 0.85; nine trials; 4664 participants; high quality evidence). The authors estimated that hand washing may prevent a similar proportion in low- and middle-income countries but only two trials from urban Egypt and Kenya were included in the review (RR: 0.66; 95% CI: 0.43, 0.99; 2 trials; 45 380 participants; low quality evidence).	
Evans et al., 2012 (59)	1.1, 4.1 This systematic review and meta-analysis of interventions to increase F&V intake in children aged 5–12 years found that school-based interventions moderately improve fruit intake but have minimal impact on vegetable intake.	The review included 27 studies which consisted of randomized and non-randomized controlled trials published between 1996 and 2008.	School-based interventions to increase F&V intake, focusing solely on F&V or as part of wider objective to promote healthy diets. Specific interventions included nutrition education (as part of school curriculum or through messages), involvement of school community or parents (projects for parents-children, newsletters, teacher-student communications), provision of F&V or healthy foods, food preparation and/or tasting during school. The majority were multicomponent programmes; whereas single-component programmes were mainly free or subsidized fruit-distribution schemes.	Children aged 5–12 years (n=26 361) in primary schools in the United Kingdom, Netherlands, the United States and New Zealand.	Meta-analysis on 21 of the 27 studies found that F&V intake increased by 0.25 portions/day (95% CI: 0.06, 0.43), mainly due to increases in fruit consumption. Separate analyses for fruit consumption showed an increase of 0.24 portions/day (95% CI: 0.05, 0.43) and for vegetables a non-significant increase of 0.07 portions/day (95% CI: -0.03, 0.16); however, heterogeneity was moderate to high. The pooled estimates for single-component programmes were smaller, although heterogeneity was higher than for all studies combined. The authors concluded that school-based interventions moderately improve fruit intake but have minimal impact on vegetable intake. They also noted that multicomponent programmes tended to result in larger improvements while single component interventions, including free and subsidized F&V distribution schemes, tended to be less effective, although there were too few studies included to make firm conclusions.	

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Feng et al., 2017 (56)	1.1, 3.2, 5.1, 5.2	This meta-analysis of 76 studies of school-based obesity interventions in China concludes that comprehensive school-based interventions involving PA and health education are more effective than the PA only interventions.	The review included 30 randomized and 46 non-randomized controlled trials published between 1997 and 2015.	Interventions to prevent (36 studies) or treat (40 studies) obesity (but not to treat obesity complications such as type 2 diabetes, hypertension). The most common interventions were PA and health education, other interventions included dietary improvement (e.g. directly modifying school lunches), weight management (i.e. weight monitoring and guidance among overweight and obese children), school policies, psychological counselling, physical infrastructure support (e.g. upgrading sport facilities). Forty-seven studies used comprehensive interventions with multiple components.	Children aged 6–19 years (n=72 620) in primary and secondary schools in China.	More treatment studies were effective in at least one anthropometric outcome (e.g. BMI, weight status, waist or hip circumference, skin fold thickness, body fat percentage) between the intervention and control groups ( $P < 0.05$ ) compared with prevention studies (85.0% vs. 58.3%). The comprehensive interventions involving PA and health education were more effective than the PA only interventions for treatment and prevention studies. Among the prevention studies targeting all children, 19 of 27 multicomponent interventions (70.4%) vs 2 out of 9 single components (22.2%) were effective. Among the multicomponent prevention studies, the most effective studies were those combining PA and health education (15 out of 19, 78.9%). Among those combining other interventions, all the effective studies (4 out of 8, 50%) combined health education with weight management. The meta-analyses showed comprehensive interventions involving PA and health education had a larger effect on the change of BMI than PA only interventions in both treatment studies [(SMD: -1.80; 95% CI: -2.15, -1.44) vs. (SMD: -0.91; 95% CI: -1.15, -0.67)] and prevention studies [(SMD: -0.19; 95% CI: -0.27, -0.11) vs. (SMD: +0.05; 95% CI: -0.04, +0.15)].

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Frerichs et al., 2015 (124)	3.1, 4.1, 4.2, 4.4, 4.5, 4.6	This systematic review of 102 studies of school architecture and design found evidence that a range of physical factors contribute to creating supportive, healthy-eating school environments.	The review included 102 studies published between 1996 and 2014. Thirty-nine studies contributed to the qualitative findings, 59 contributed to quantitative findings and 4 used mixed methods and contributed to both.	Interventions that had a physical environment component contributing to intervention impact.	Children in primary and secondary schools globally, but most studies were conducted in the United States.	Analysis of 31 studies of food service in schools found negative effects on food choices from short school meal times, long cafeteria service lines or easy access and appeal of unhealthy snacks and competitive foods. Analysis of 23 studies of water access and vending machines found negative effects from limited access to and poor quality of water or from presence of less healthy items in vending machines. Studies on the effect of different foods in vending machines had mixed results; 3 of 7 studies observed associations between increased access to less healthy items and poorer dietary behaviours. Six of 9 studies on water access found improvements in water intake, but not in terms of reduced SSB consumption. Twelve of 16 studies found that increased accessibility of healthy items or decreased accessibility of less healthy items improved dietary behaviours measured by sale, self-reported data or plate waste. Analysis of 21 studies of school garden on-site food production found that these could easily be integrated into curricula and have benefits beyond improved dietary behaviour; however, barriers such as intensive time and resource requirements were identified. Analysis of 14 studies on school teaching kitchens found that these were popular among staff and students, and could easily be integrated with other academic topics. Five of 7 studies found significant increases in the consumption of, for example, vegetables. Analysis of 15 studies of educational signage, wayfinding and marketing found that these approaches are acceptable strategies to students, parents and teachers for addressing healthy eating in schools, though results were mixed and often not sustained. Analysis of studies of the dining or kitchen domain found that overcrowding in the cafeteria contributed to students' negative social experiences whereas lack of appropriate kitchen facilities and equipment hindered schools' ability to provide meals with high nutritional quality and appeal.

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Friedrich, Schuch and Wagner, 2012 (53)	1.1, 3.1, 3.2	This systematic review and meta-analysis of 23 RCT studies found that combined PA and nutrition education interventions in the school setting were more effective in improving BMI than either PA or nutrition education in isolation.	The review included 23 RCTs published between 1999 and 2010.	Five studies included only PA interventions, 2 included only nutrition education and 16 included both PA and nutrition education. All of the studies encouraged healthy diets through presentations and didactic materials; 7 studies also had interventions with school meals and cafeterias.	Children and adolescents aged 7–17 years in the school setting (n=17 693), primarily in the United States and Europe, but also China, Australia, India and Israel.	Results of the meta-analysis showed that the studies with combined PA and nutrition education resulted in significant improvements in BMI (SMD: -0.37; 95%CI: -0.63, -0.12; 16 studies; 9997 participants), whereas neither the 5 isolated PA interventions nor the 2 isolated nutrition education interventions resulted in significant improvements in BMI.
Girum and Wasie, 2018 (184)	5.3	This systematic review and meta-analysis of 8 school-based deworming programmes found an overall improvement in haemoglobin after deworming, with the greatest impact on anaemia rates in studies that combined deworming with hygiene promotion and/or co-administration of iron and retinol.	The review included 8 studies (5 cross-sectional and 3 RCTs) published between 1998 and 2015.	School based deworming programmes where children received at least one or more round of deworming six months apart and were followed for at least a year.	Children (n= 1 005 239) in preschool, primary and secondary school setting in India, Nigeria, the United Republic of Tanzania, Thailand and Viet Nam.	Meta-analysis of 5 studies found an overall improvement in haemoglobin after deworming (1.62 g/dl; 95%CI: 1.01 g/dl, 2.25 g/dl). The prevalence of anaemia was markedly changed in individual studies that combined deworming with hygiene promotion and/or co-administration of iron and retinol.

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Gordon, Dynan and Siegel, 2018 (136)	3.1, 4.1, 4.2	This systematic review of 48 school cafeteria studies found that interventions that change the environment to favour fast and intuitive thinking for selecting healthier options were both more common and more effective than interventions that favour slow and cognitively demanding choice through educating children.	The review included 48 studies (17 RCTs and 31 cross-over interventions) published between 2012 and 2017.	Various cafeteria interventions, which were grouped by the behavioural economics theory of Kahneman into "system 1" (fast and intuitive thinking), "system 2" (slow and cognitively demanding) or both. "System 1" interventions include changes in price, colour grouping, affective cues (i.e. emoticons), placement of F&V, express lines, creative names and attractive labels, advertising and other environmental changes such as exposure, convenience, incentives, labelling, messaging (e.g. banners, announcements), and references to social norms. "System 2" interventions include classroom nutritional education, nutritional information posting and educational programmes outside the classroom.	Children and adolescents in elementary, middle and high school. Geographical location not indicated.	Defining success as a 30% improvement in a desired outcome (i.e. change in consumption and/or selection of fruits, vegetables, sugary drinks, plain milk and whole grains) or statistically significant reduction in BMI, the authors found that 24 of 27 (89%) of "system 1" studies were successful vs. 8 out of 13 (62%) of mixed studies and 4 out of 8 (50%) of "system 2" interventions. "System 1" studies were significantly more effective than "system 2" studies ( $P = 0.033$ ), but no significant difference in effectiveness was observed between any of the other intervention groups when compared. Nine out of 11 studies using incentives were successful as were all 5 studies using emoticons, whereas 1 out of 3 studies using messaging was effective. However, the authors note that as the latter was a single component study, this demonstrates that messaging alone may significantly increase consumption of vegetables.

AUTHOR, YEAR	MFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Gori et al., 2017 (49)	1.1, 2.2, 3.2	This review and meta-analysis of 72 studies in overweight or obese primary school age children, 47 of which were school-based, found largest effect on BMI z-score from combined school-based diet and PA interventions with a family component.	The review, updating a previous review and meta-analysis by Waters et al. (2011), included 72 studies (RCT and non-randomized controlled trials) of interventions lasting $\geq 12$ weeks, published between 1993 and 2016.	Interventions focused on diet (8 studies), PA (22 studies) or both (42 studies), compared with standard care. Dietary interventions usually consisted of prescribing a daily diet following recognized guidelines, monitored through a detailed nutrition diary with feedback provided by specifically trained operators. The approaches were typically educational, but some also changed the environment and were complemented by counselling by school health nurses or involved parents.	Overweight and obese children aged 2–18 years, in school and/or family setting (47 studies); included a school component). Studies were worldwide, though mostly from HIC.	The update added 35 new studies to the previous review by Waters et al. (2011) of 37 studies. Among 47 results conducted in school or combined school/family setting, significant results were found for combined diet/PA in children aged 6–12 years (mean BMI z-score: -0.13; 95% CI: -0.19, -0.06; 12 studies) or PA alone (mean BMI z-score: -0.11; 95% CI: -0.16, -0.06; 14 studies) in the school setting, though the best results were achieved for combined diet/PA in children aged 6–12 years in a combined school and family setting (mean BMI z-score: -0.15; 95% CI: -0.21, -0.03; 6 studies). No significant results were found for other subgroup analyses for this or other age groups (2–5 years, 13–18 years) for any intervention or setting combination.
Guerra et al., 2014 (66)	1.1	This systematic review and meta-analysis of 38 studies on school-based combined PA and nutritional education interventions did not show significant reductions in BMI.	This review included 38 RCTs published between 1988 and 2012.	Combined nutrition education and PA interventions.	Children aged 6–17 years (n=28 870) in schools largely in the United States and Europe, but also in Australia, Israel, China, India and New Zealand	The main analysis showed an insignificant improvement in BMI between intervention and control groups (SMD: -0.03; 95% CI: -0.09, 0.04) for combined PA and nutritional education interventions. The research, which was done as part of a larger project analysing effectiveness of PA alone (Guerra et al., 2013) or nutrition education alone (Silveira et al., 2013), showed that only nutrition education alone was effective; however, this had been driven by one study.

NFS ESSENTIAL		STUDY SETTING AND RESULTS OF REVIEW			
AUTHOR, YEAR	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	POPULATION	RESULTS OF REVIEW
Hamel and Robbins, 2013 (128)	3.1 This systematic review of 15 studies concludes that computer-based and web-based interventions can improve eating behaviours and diet-related physical outcomes among children and adolescents.	The review included 15 RCTs or quasi-experimental studies.	5 computer-based and 10 web-based interventions to promote healthy eating among children and adolescents.	Children and adolescents aged 6–18 years, mostly in the school setting (10 of 15 studies) and largely in the United States but also in Europe (Belgium, France, the Netherlands).	Although 11 of the 15 interventions resulted in statistically significant positive changes in eating behaviour or diet-related physical outcomes (e.g. BMI, weight, % body fat and waist circumference), studies that included post-intervention follow-up, ranging from 3–18 months, showed that changes were not maintained. Conducting the intervention at school or using individually tailored feedback enhanced success. The authors suggest that the closely supervised environment of a classroom, along with the potential for social support from teachers or fellow classmates, may enhance the effect of a school-based intervention over a home-based approach that may be completed alone.
Hersch et al., 2014 (141)	3.3 This systematic review of 8 studies on (largely school-based) cooking classes for children showed beneficial results in food preparation skills, F&V consumption, F&V preference and blood pressure, as well as BMI among overweight or obese children aged 5–12 years.	The review included 8 RCT and quasi-experimental studies published between 2003 and 2014.	Cooking education programmes for children with food preparation lessons, as part of curriculum (6 studies), after school programme (1 study) or in the evening (1 study). Three of the studies engaged parents, either through separate lessons or a newsletter that was sent home.	Children aged 5–12 years in the primary school setting in the United States	Significant results were observed in 2 of 2 studies measuring children's willingness to try new foods, 4 out of 4 studies measuring food preparation skills and cooking confidence, 5 out of 5 studies measuring consumption of daily F&V servings (4 showed a significant increase in F&V and 1 showed a significant increase in fruit only), 2 out of 2 studies analysing the preference for F&V, and in 1 study measuring blood pressure. Nonsignificant changes in BMI among all children were observed in 2 out of 2 studies measuring this; however, one of them found a significant decrease in BMI among overweight and obese participants.

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Hingle et al., 2010 (94)	2.2	This systematic review of 24 studies, 16 of which were school-based, found that direct methods to engage parents in dietary interventions, such as parent attendance of educational or counselling sessions, were more likely to result in positive changes in dietary outcomes compared to indirect methods of parental involvement.	The review included 24 RCT studies published between 1988 and 2008.	Obesity prevention, chronic disease prevention or health promotion interventions involving a parent component, either directly (e.g. presence in nutrition education sessions, participation in family behaviour or counselling or parent training sessions) or indirectly (e.g. newsletter or provision of information that did not require response, invitations to participate in nutrition activities).	Children and adolescents aged 2–18 years primarily in the United States, but also Australia, Belgium, and France, mostly in the school setting (16 studies) but also in the community (8 studies).	All 5 studies using direct methods achieved at least some positive dietary change (e.g. saturated fatty acid, sodium, energy and F&V intake) (2 positive and 3 mixed outcomes), while only 64% of the 19 studies using indirect methods achieved positive changes in dietary or adiposity outcomes (7 positive, 7 mixed and 5 no effect). Among those using indirect methods, studies requiring that children engage their parent in an activity were most likely to report positive or mixed results. Limited conclusions may be drawn regarding the best method to involve parents in changing child diet to prevent obesity and improve health. Indirect methods remain the most commonly used strategies to engage parents; however, direct methods of engagement show more promise and therefore warrant further research.
Howerton et al., 2007 (60)	1.1, 3.1	This systematic review and meta-analysis of 7 studies found that school-based nutrition interventions produced a moderate increase in F&V consumption among children.	The review included 7 studies (2 cross-sectional quasi-experimental studies, 2 pre- and post-test design, a randomized paired design, a randomized field trial and a randomized community trial) published between 1998 and 2000.	School-specific interventions to increase F&V consumption among children. Each study implemented at least 2 strategies to deliver the interventions, with each study including a classroom-based component. Additionally, 6 of the studies included a family component, 4 studies included a food-service component, 2 studies included a community component, and 1 study included a media campaign.	Children aged 7–12 years (n=8156) at primary schools, mostly in the United States.	School-based nutrition interventions appear to produce a moderate increase in F&V consumption among primary school children. In the analysis of study-level effect sizes, the combined estimate of the net differences in F&V intake was 0.38 servings (95% CI: 0.31, 0.44) and the relative change was a 21% (17% to 25%) increase in F&V intake. F&V consumption increased by about half of a serving at the individual level. In the pooled data, the intervention groups consumed 0.45 more F&V servings than the control groups (95% CI: 0.33, 0.56).



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Hung et al., 2015 (65)	1.1	This meta-analysis of 27 school-based childhood obesity prevention programmes did not provide strong evidence that such programmes are effective; moreover, single component programmes were more effective than multicomponent programmes.	The review included 27 school-based childhood obesity prevention programmes of various designs (RCTs, CCTs, intervention with control group, cohort) published between 1988 and 2013.	School-based childhood obesity prevention programmes (nutrition, PA and/or parental involvement). Twenty-one of 27 studies included a nutrition component.	Children and adolescents aged 6–18 years (n=26 114), in the school setting mostly in the United States but also in Europe, Australia and Chile.	In a meta-analysis of 54 SMD effect sizes based on BMI or skinfold thickness outcomes, there was not strong evidence that school-based programmes have been effective in improving children's BMI or skinfold thickness values. Significance of SMD was defined as small (up to 0.20), medium (up to 0.50) or large (0.80 or greater). The weighted summary effect size for all 54 effect sizes was small (SMD: 0.039; 95% CI: -0.013, 0.092; P=0.145). A meta-analysis of 18 effect sizes from interventions that contained only one programme component resulted in larger yet small effects (SMD: 0.112; 95% CI: 0.054, 0.17; P<0.001). Conversely, a meta-analysis of interventions with two or more programme components resulted in a very small effect size of 0.003 (95% CI: -0.064, 0.070, P=0.935) with extreme heterogeneity. Programs that contained only one moderator (PA or nutrition) and an RCT design produced an effect size of 0.168 (95% CI: 0.085, 0.252) with no heterogeneity.

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Jaime and Lock, 2009 (37)	1.1, 4.1	This systematic review of 27 studies of school food and nutrition policies examining the impact of nutrition policy on nutrition outcomes found that some policies may improve the food environment and dietary intake but found no evidence for impact on BMI.	The review included 27 randomized and non-randomized controlled trials, published between 1991 and 2007.	School food or nutrition policies (e.g. nutrition guidelines, regulation of food and beverage availability, price intervention).	Children and adolescents aged 2–18 years, from preschools (1 study), primary (7 studies) and secondary schools (10 studies) in the United States and Europe.	Most evidence of effectiveness was found for the impact of both nutrition guidelines and price interventions on intake and availability of food and drinks, with less conclusive research on product regulation. Some current school policies have been effective in improving the food environment and dietary intake in schools, but there is little evaluation of their impact on BMI. Food and nutrition policies had effects on menu composition. Three out of 4 studies measuring fat content in menus found that the intervention schools had a significant decrease in total and saturated fat on the school menus. All 4 studies of interventions to increase F&V offered showed that guidelines led to increased fruit and vegetable availability (+0.28 to +0.48 servings/day). All three studies measuring fat intake found significant decreases in total fat or saturated fat (-2.0% to -10.9% and -0.9% to -5.2%, respectively), and both studies measuring fruit and vegetable intake showed a positive impact (+0.30 to +0.37 servings/day). Both studies that measured the impact of restrictive nutrition policies on sales of food and beverages suggested a significant but limited decrease in the sales of banned foods, such as chips and SSBs, and both studies that measured the impact of reducing low-fat food prices showed significant increases in low-fat snacks and F&V sales. The one study that evaluated effect on BMI reported no difference between groups at 1 year of follow-up.

NFSI ESSENTIAL CRITERIA		STUDY SETTING AND POPULATION			RESULTS OF REVIEW	
AUTHOR, YEAR	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	POPULATION	RESULTS OF REVIEW	
Jasper, Le and Bartram, 2012 (171)	4.6, 4.7 This systematic review of 47 water and sanitation interventions in schools found that water provision and adequate sanitation and water facilities are beneficial to children's health.	The review included 47 studies comprised of 9 intervention trials, 4 RCTs, 1 observational study, 1 participatory research study, 4 descriptive studies, 26 cross-sectional studies and 2 outbreak investigations.	Water and sanitation interventions: 11 addressed drinking water, 7 addressed water for handwashing, 5 addressed providing water for drinking and handwashing, 6 addressed sanitation, 4 addressed sanitation related to menstruation facilities, and 14 addressed providing water and sanitation combined in schools.	Children in school setting in HIC and low- and middle-income countries, globally.	Of relevance to nutrition, 20 studies reported infectious disease outcomes including diarrhoea. There was a reported decrease in diarrhoeal and gastrointestinal diseases with increased access to adequate sanitation and handwashing facilities and supplies in schools. Furthermore, 2 studies reported overweight related measures, one of which reported a 31% reduction in the risk of overweight associated with providing drinking water and education in schools.	
Jensen et al., 2011 (158)	4.2 This systematic review of 30 school-based studies found that economic incentives may influence school children's choice of foods, snacks and beverages	The review included 30 studies of both empirical and experimental design including RCTs, cross sectional, simulation experiments, quasi-experimental, published between 1994 and 2009.	Economic incentives for students and their families using direct incentives (e.g. price differences between nutritious and non-nutritious foods, rewards such as pens or other small items or participation in a raffle) and/or for schools and communities using indirect incentives (e.g. compensation for efforts devoted to promotion of healthy nutrition, reward upon achievement of specific goals).	School-aged children (or sometimes their parents) in primary or secondary schools largely in the United States as well as in Europe.	In general, the studies supported the hypothesis that both direct and indirect economic incentives affect food and beverage choices. The authors concluded that price differences between nutritious and non-nutritious foods were effective for altering consumption in school cafeterias or from vending machines and for increasing F&V consumption at schools in contexts where foods or beverages are offered (for sale) at the schools and students (typically 10–12 years or older) bring money to school to buy some of these items. The studies on small rewards as incentives were usually implemented in combination with extensive educational activities, thus the authors were unable to draw any conclusions on the effect of the incentives. Compared to these direct economic incentives, the evidence of indirect incentives was somewhat weaker.	
Johnson, Weed and Touger-Decker, 2012 (71)	1.1 This systematic review of 7 school-based multicomponent programmes in minority elementary schools in the United States found some benefits in health behaviours and anthropometric measures.	The review included 7 studies (RCTs, non-randomized controlled trials, cohort studies) published between 1996 and 2010.	Multicomponent school-based overweight and obesity programmes that included nutrition education, optimization of the school food environment and/or PA.	Children in elementary schools with large minority populations in the United States.	All studies reported some benefits in health behaviours and/or anthropometric measures, 5 of which reported a positive benefit on overweight or adiposity. The authors noted that effectiveness was greater when programme objectives were specific, implemented across the school environments, extended into the community and were culturally relevant.	

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Jomaa, McDonnell and Probart, 2011 (156)	4.1	This review found positive effects of 13 school feeding studies on energy intake, micronutrient status, school enrollment and attendance of the children.	The review included 13 studies (RCTs, intervention control studies, crossover design studies, and effectiveness reports of existing school feeding programmes) published between 1996 and 2010.	School feeding programmes (breakfast, lunch, snacks, provision of fortified foods). All types of school feeding were included (e.g. meals based on staples, snacks, fortified snacks and drinks).	Primary school aged children in the school setting in developing countries.	There is a relatively consistent positive effect of school feeding programmes on energy intake and micronutrient status of school-aged children, and a decline in infections and morbidities, particularly for programmes in which micronutrient fortification and deworming are provided to populations with a high prevalence of micronutrient deficiencies and worm infections. Mixed findings were reported from studies in terms of the impact of school feeding on weight, height and BMI gains among school-aged children. Long-term studies that assess the benefits of school meals, snacks and take-home rations on children's growth and household food consumption patterns are still lacking.
Jourdan et al., 2016 (98)	2.2,3,3	This scoping review of 11 studies of multi-setting NCD prevention programmes involving children in the design or implementation found that positive effects were observed at organizational level, in children and in adult stakeholders.	The review included 11 studies published in 12 papers between 2002 and 2014. Designs were mainly case studies (single or multiple) as well as one RCT.	School- and community-based interventions with a child involvement component, where children are consulted and provide suggestions to adult stakeholders regarding the school programme or where children take responsibility for and influence decisions. Most studies also included a community/family collaboration component.	Children, neither age nor geography specified. Most interventions were done in the school setting with community involvement (8 interventions) and a few were mainly based in the community with school involvement (3 interventions).	Positive effects were identified at the organizational level (e.g. policies to enhance F&V availability or structural changes to create opportunities for PA), in adult stakeholders (e.g. healthier eating) and in children (e.g. healthier eating, knowledge, self-efficacy, leadership). However, the number of relevant studies were few and had methodological challenges.

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Katz et al., 2008 (54)	1.1, 2.2, 3.2	This systematic review and meta-analysis examined the influence of school-based interventions on body weight, finding that combinations of nutrition and PA interventions are effective at achieving weight reduction.	The review included 19 studies (21 papers), of which 14 were RCTs and 5 were non-randomized controlled trials, published between 1985 and 2004.	School-based interventions related to nutrition, PA, reduction in television viewing or combinations thereof, aimed to prevent unnecessary weight gain or manage weight. Interventions utilized multiple approaches including information sessions, practical hands-on skill building, teacher training and school cafeteria modifications.	Children aged 3–18 years, mostly in the United States. Most studies took place in elementary schools, with a few in middle and high schools and 3 targeted high schools.	Results from the meta-analysis of 8 studies of combined nutrition and PA interventions involving 10 752 children showed significant reduction of body weight in children (SMD: -0.29; 95% CI: -0.45, -0.14; P=0.0002). These interventions were equally effective as the single nutrition intervention (SMD: -0.39; 95% CI: -0.56, -0.23) and the single television reduction intervention (SMD: -0.35; 95% CI: -0.63, -0.06), whereas the single PA intervention did not show body weight reduction. The authors concluded that a major contributing factor to the success of combined nutrition and PA interventions may have been the nutrition component. Pooling the results of the 4 studies with a parent/family component, the combined diet and PA intervention improved body weight in schoolchildren (SMD: -0.20; 95% CI -0.41, 0.00; P=0.05).
Knai et al., 2006 (79)	1.1, 2.2, 2.3, 3.1, 4.1	This systematic review of 15 studies, 14 of which were school-based, found that interventions had a significant effect of increasing F&V intake in children and the evidence is strongest in favour of interventions using multiple approaches.	The review included 15 studies (in 17 articles) of which 11 were RCTs and 4 were non-randomized controlled trials published between 1997 and 2004.	Interventions to promote F&V consumption (e.g. classroom and non-classroom-based education, changes to the environment, parent involvement, training for staff) delivered as single or multi-approach interventions.	Children and adolescents aged 5–18 years, at schools in the United States, United Kingdom and Ireland. All studies except one were conducted in the school setting.	The strongest evidence to increase F&V consumption in children was found for multi-approach interventions. Of the 15 studies reviewed, 10 had a significant positive effect on F&V consumption, ranging from +0.3 to +0.99 servings/day, particularly in primary schools. Significant improvements in F&V intake were seen in 8 out of 11 studies with a parental involvement component and 3 out of 4 studies with a community involvement component, 6 out of 9 studies with increased exposure to F&V in the school setting (e.g. canteens), 6 out of 10 studies modifying lunches or snacks provided, 6 out of 9 studies integrating F&V knowledge or preparation into the curriculum, 8 out of 11 studies including a teachers' training component, 7 out of 9 including a school food service staff training, and 1 out of 2 studies with a school nutrition council or policy.

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Kong, Liu and Tao, 2016 (174)	3.1	This systematic review and meta-analysis of 17 school-based nutrition education interventions for obesity in China found significant impact of interventions among studies with higher methodological qualities and in studies where the duration was longer than 2 years. The effect of nutrition education on obesity was smaller than the effects of interventions aimed at preventing malnutrition and iron-deficiency anaemia.	The review included 17 studies on school-based nutrition education, of which 16 had intervention and control groups whereas one used pre- and post-test design without a control group. In addition, 9 studies were included in a comparative meta-analysis of nutrition education to address undernutrition.	School-based nutrition education interventions for obesity including nutrition education, health education and PA. Comprehensive approaches were aimed at facilitating dietary behaviour changes and increasing PA. Several studies engaged parents, teachers or school personnel in addition to the children. Nutrition education interventions aimed at undernutrition were included for the comparative analysis.	Children in primary schools in China.	Overall, the studies showed no significant impact of nutrition education on obesity (OR: 0.76; 95% CI: 0.55, 1.05; $P=0.09$ ). However, when 3 studies with unbalanced baseline characteristics between groups and selection bias in the study subjects were excluded, the impact of nutrition education on obesity in the remaining 14 studies involving 17 277 children was significant (OR: 0.73; 95% CI: 0.55, 0.98; $P=0.03$ ). An analysis stratified according to the duration of intervention revealed that the intervention was effective only in the 2 studies involving 6029 children that lasted for more than 2 years (OR: 0.49; 95% CI: 0.42, 0.58; $P<0.00001$ ). The authors concluded that school-based nutrition education is a feasible and cost-effective strategy that helps children develop healthy habits at early age; however, such studies undertaken in China have some important limitations (i.e. inadequate intervention duration, inappropriate randomization methods, selection bias, unbalanced baseline characteristics between control and intervention groups, and absent sample size calculation) that might affect the estimated effectiveness of the intervention. By comparison, interventions aimed at preventing childhood malnutrition had a pooled OR of 0.68 (95% CI: 0.64, 0.71; $P<0.0001$ ; 3 studies) and those aimed at preventing iron-deficiency anaemia had a pooled OR of 0.49 (95% CI: 0.33, 0.72; $P<0.001$ ; 5 studies).

NFSI ESSENTIAL CRITERIA		STUDY SETTING AND RESULTS OF REVIEW			
AUTHOR, YEAR	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	POPULATION	
Krishnaswami et al., 2012 (90)	2.2 This systematic review and meta-analysis of 16 studies found a positive relationship between levels of community engagement and outcome performance in school-based interventions related to diet, PA and body weight.	The review included 16 studies of various designs (RCTs, matched-control experiments and observational and quasi-experimental) published in peer-reviewed journals between 2000 and 2011.	School-based obesity prevention interventions focusing on diet, PA and body weight with different level of participatory involvement from communities according to a computed "community engagement performance" score based on capacity-building components and level/depth of partner involvement across four research stages (e.g. targeting long-term impact, removing environmental barriers to participation or behaviour, building leadership, promoting self-esteem and empowerment, establishing channels for funding or equipment, and addressing system-level and policy components).	School-aged children (mean age 10.7 years), involving diverse groups (African-American, Hispanic, Native American, rural, urban, low-income) with at least 30% minority/low-income status in the United States.	Obesity prevention interventions with greater school-community partnership achieved more weight-, diet-, and PA-related outcomes in diverse school-age populations compared to interventions with less community engagement. Overall community engagement performance but not specific community engagement characteristics (e.g. research stage, partner type, or number of involved partners) was positively correlated with outcomes ( $r=0.66$ ; 95% CI: 0.25, 0.88), suggesting that a greater degree of community engagement is linked to greater achievement of intervention outcomes. The 2 studies with the highest community engagement performance scores achieved the highest outcome performance. In an analysis of the specific community engagement features, positive community engagement-outcome correlations were present for interventions involving partners in needs assessments ( $r=0.77$ ; $p=0.04$ ) but not for those without such involvement. The authors concluded that involving communities in needs assessments and goal-setting appeared to promote outcomes by increasing community support for the intervention, facilitating subsequent implementation and well-tailored design.

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Kristjansson et al., 2007 (148)	4.1	This Cochrane review and meta-analysis of 18 studies on the effectiveness of school feeding programmes found that school meals resulted in small improvements in weight, height in younger children, attendance, math performance and behaviour, especially in disadvantaged children.	The review included 18 studies comprised of 7 RCTs, 9 CBA studies, and 2 interrupted time series. Studies were published between 1926 and 2004.	School feeding programmes including meals (breakfast or lunch) or snacks (including milk), fortified or non-fortified, compared against no meals or snacks provided.	Children aged 5–19 years at schools (mostly primary schools) in HIC (9 studies) and LIC (9 studies).	In LIC, children who were fed at school gained more weight than controls over the study duration [0.39 kg (95% CI: 0.11, 0.67); 1462 participants; 3 studies] over an average of 19 months in the RCT studies and 0.71 kg (95% CI: 0.48, 0.95) over 11.3 months in the CBA studies. Children who were fed at school attended school more frequently than those in control groups. For height, results from LIC were mixed; in RCTs, differences in gains were important only for younger children (0.40 cm; 95% CI: 0.03, 0.77; 1226 participants; 3 studies), but results from the CBAs were large and significant (1.43 cm; 95% CI: 0.46, 2.41; 986 participants; 6 studies). Results for height from HIC were mixed, but generally positive based on one RCT and one CBA study. For educational and cognitive outcomes, children who were fed at school gained more than controls on math achievement and on some short-term cognitive tasks. Results from HIC were mixed, but generally positive. The authors conclude that school meals may have small physical and psychosocial benefits for disadvantaged students.
Kropski, Keckley and Jensen, 2008 (85)	1.1.3.2	This systematic review of 14 school-based obesity prevention programmes of at least 6 months duration found that such interventions may be effective for certain populations.	The review included experimental or quasi-experimental study designs, including RCTs and cohort concurrently controlled trials, published between 1993 and 2005.	School-based obesity prevention programmes of a duration of 6 months to 6 years, focusing on nutrition (e.g. food service, nutrition education), PA (e.g. PE, fitness) or both.	Children aged 4–13 years at school in multiple countries, mostly in the United States but also in Chile, Germany, Thailand and the United Kingdom.	The one nutrition study reported a reduction in overweight (but significance was not reported). One out of 2 PA studies and 5 of 11 combined studies reported significant effects in at least one subgroup. Pooling of data for meta-analysis was not possible due to inconsistent reporting of specific outcome measures and measures of error. The authors concluded that school-based obesity prevention programmes may be effective for certain populations. They noted that the highest quality study reviewed found a large and significant reduction in odds ratio for overweight in girls.



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Langford et al., 2014 (46)	1.1.2.2, 3.2	This systematic review and meta-analysis of 67 studies (of which 34 concerned diet and/or PA) provide evidence for the effectiveness of some interventions based on the WHO HPS framework for improving certain health outcomes but not others.	The review included 67 studies of cluster RCTs that had multiple schools in each group, where clusters were at the level of school, district or other geographical area. Studies were published between 1992 and 2013.	Interventions implemented through the three HPS framework strategies: curriculum, environment and families/communities (e.g. health education promoted through formal school curriculum, changes to the school's physical and/or social environment, engagement with families and the wider community). The specific interventions included diet and/or PA interventions, as well as other health issues. The 34 studies focusing on diet and/or PA included diverse intervention approaches (e.g. nutrition education, F&V schemes, changes in school cafeterias, curricular and extracurricular PA).	Children aged 5–15 years in primary and secondary schools worldwide, largely in HIC (the United States, Europe, Australia, New Zealand), but also in LMIC (China, Mexico), LMIC (India, Egypt) and a LIC (United Republic of Tanzania).	Various subgroup meta-analyses by intervention type were performed of the 34 nutrition and/or PA interventions using the HPS approach. Only PA interventions alone (3 trials) were able to reduce BMI significantly (MD: -0.38 kg/m <sup>2</sup> ; 95% CI: -0.73, -0.03; 1430 participants), whereas 1 nutrition only study and 9 combined nutrition/PA studies did not show significant effect on BMI. There was little evidence of an effect on BMI when age and gender were taken into account using BMI z-score; only the single PA intervention measuring this outcome showed a significant effect (MD: -0.47; 95% CI: -0.69, -0.25; 196 participants), whereas the reductions seen from 1 nutrition only study or from 7 combined nutrition/PA studies were insignificant. The pooled results from 9 nutrition studies demonstrated significant increase in F&V intake (SMD: 0.15; 95% CI: 0.02, 0.29; 6210 participants), but the increase was significant for the 4 combined nutrition/PA studies. The reductions in fat intake when pooling results from 7 nutrition only studies or from 10 combined nutrition/PA studies were insignificant. The authors concluded that holistic school-based interventions, like those proposed in the HPS framework, can be effective at improving a number of health outcomes in students.

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Langford et al., 2015 (97)	2.2, 2.3	This systematic review of 26 school-based diet and PA studies aligned to the WHO HPS framework found that working with teachers, providing ongoing training and support and tailoring of programmes accentuated results, while family involvement was challenging.	The review included 26 cluster RCTs with process evaluation data published between 1996 and 2013. These studies were drawn from 34 studies focusing on diet and PA out of 67 studies included in a review of the effectiveness of the HPS framework published in 2014.	The programme interventions focused on diet and/or PA and were implemented through the three HPS framework strategies: curriculum, environment and families/communities (e.g. health education promoted through formal school curriculum; changes to the school's physical or social environment, engagement with families and the wider community).	Children aged 5–15 years in primary and secondary schools in the United States, Europe and Australia.	School-based diet and/or PA programmes following the HPS framework were shown as effective at increasing PA, fitness and F&V intake in schoolchildren (Langford et al., 2014). Further process evaluations revealed high levels of acceptability among teachers and students, but implementation fidelity varied considerably across trials. Involving families, despite being a key part of the HPS approach, was reported as highly challenging due to factors such as language barriers, misunderstanding the purpose of the programme and lack of time or opportunity. Intervention elements identified as important included: tailoring programmes to individual schools' needs; aligning interventions with schools' core aims; working with teachers to develop programmes and increase ownership; and providing on-going training, support and communication. The emphasis on academic subjects (and the corresponding low value placed on health initiatives), and lack of institutional support were cited as barriers to implementation, as was lack of space for PA, and lack of motivation of school canteens to introduce healthier foods that may not be popular and therefore not financially viable.
Lavelle, Mackay and Pell, 2012 (55)	1.1, 3.2	This meta-analysis of 43 studies on school-based interventions found significant evidence that these interventions can significantly reduce children's BMI, especially if they include a physical exercise component.	The review includes 43 studies (cluster RCT, efficacy trial, quasi-experimental, pilot RCT, quasi-RCT, pilot prospective study) published between 1991 and 2010.	Interventions were comprised of PA only in 11 studies (26%), education only in three (7%) and combinations of these and improved nutrition in the remaining 29 (67%). Among the 43 studies, 34 included PA, 6 included an environmental component (e.g. changes to school meals or installation of healthy vending machines) and 28 included education on nutrition.	Children aged ≤18 years (n=36 579) in pre-, primary and secondary schools in the United States, Australia, Germany, Spain, Brazil, France, Netherlands, India, Canada, Singapore, Egypt, Belgium, Ireland, China, Chile, Switzerland, Greece, Thailand and United Kingdom.	Meta-analysis showed a significant reduction in BMI overall for all studies (-0.17 kg/m <sup>2</sup> ; 95% CI: -0.08, -0.26; P=0.001), for PA used in isolation (-0.13 kg/m <sup>2</sup> ; 95% CI: -0.22, -0.04; P=0.001) and combined with improved nutrition (-0.17 kg/m <sup>2</sup> ; 95% CI: -0.29, -0.06; P<0.001). Interventions targeted at overweight or obese children (-0.35 kg/m <sup>2</sup> ; 95% CI: -0.58, -0.12; P=0.003) had a greater effect on BMI than those delivered to all children (-0.16 kg/m <sup>2</sup> ; 95% CI: -0.25, -0.06; P=0.002).

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Li et al., 2008 (152)	4.1	This systematic review of 22 school-based obesity prevention or reduction interventions in China found that those including dietary modifications improved weight-related outcomes.	The review included 22 studies (12 RCTs, 6 were non-randomized controlled trials and 4 were pre- and post-test comparisons) published between 1990 and 2006.	Health education, PA and/or dietary intervention. Thirteen of the 22 studies included dietary modification intervention (e.g. increase F&V and legumes, restrict SSBs, portion size control) combined with PA and/or health education.	Children and adolescents aged 3–19 at schools in China; 17 of the 22 studies were targeted at overweight or obese children.	Overall, most studies reported a beneficial effect of the intervention with one or more of the study outcomes, but all the studies had serious or moderate methodological weaknesses. Ten of the 13 studies including dietary modification reported on weight-related outcomes and all of these studies reported effectiveness on overweight and obesity prevalence or BMI.
Lissau, 2007 (84)	1.1	This systematic review of 14 obesity prevention studies in the school arena found that multicomponent studies including a nutrition component were less often effective.	The review included 14 studies (RCTs, cluster CCTs, non-randomized controlled trials) published between 1995 and 2005.	Obesity prevention interventions (e.g. education, food service, environment) including components such as nutrition/diet and PA.	Children in primary and secondary schools, largely in the United States and Europe, as well as Chile.	Overall, half of the studies were successful and had an effect on either overweight or obesity. However, only 2 of the 6 multicomponent studies that included a nutrition component were effective.
Luckner, Moss and Gericke, 2012 (51)	1.1	This systematic review and meta-analysis of 68 single and multicomponent obesity prevention studies, of which 50 related to nutrition of children in schools, identified multicomponent interventions in schools and encouraging reduced television viewing as promising strategies to prevent obesity.	The review included 68 controlled randomized or quasi-experimental studies published between 1982 and 2008.	Single and multicomponent interventions related to nutrition (change in at least one daily meal), PA (regular exercise), television (interventions aimed at reducing television viewing) and education (dissemination of information or teaching on either general healthy behaviour or specifically related to nutrition, PA or sedentary behaviour).	Children (55 studies) and adults (13 studies) in the United States, Europe, Australia, Canada and New Zealand. Of the 55 studies focusing on children, 50 studies were school-based, 3 studies included younger children (aged <6 years), 34 included children (aged 6–12 years) and 18 included adolescents (aged 12–18 years).	In children, the highest obesity reductions were achieved through promoting reduced television viewing (MD: -0.27 kg/m <sup>2</sup> ; 95% CI: -0.4, -0.13; 8 studies), second largest through combining PA with education (MD: -0.19 kg/m <sup>2</sup> ; 95% CI: -0.37, -0.02; 2 studies) and third largest through education alone (MD: -0.15 kg/m <sup>2</sup> ; 95% CI: -0.24, -0.07; 15 studies). Only PA had an effect on percentage of body fat. In other interventions, heterogeneity was too high or showed no statistically significant reduction in outcomes.

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE-SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Luybli, Schmillen and Sotos-Prieto, 2019 (70)	1.1, 2.2	This scoping review of 15 preschool interventions in low socioeconomic settings in HIC on adiposity-related outcomes among preschoolers found that both successful and inconclusive studies were multicomponent — including nutrition, PA and parent involvement.	The review included 15 studies, 14 RCTs and 1 quasi-experimental study, published between 2005 and 2016.	Obesity reduction interventions (e.g. education, parent involvement, environmental, economic) focusing on nutrition, PA and screen time.	Preschoolers aged 2–5 years in rural, low socioeconomic or underserved settings, largely in the United States, as well as in Belgium, Germany, France, Israel, New Zealand and Switzerland.	All 19 successful interventions in terms of reducing adiposity-related outcomes (BMI z-score, waist circumference, percent body fat) were multicomponent, which included nutrition (e.g. educational nutrition lessons), PA, screen time and parent involvement. Similarly, the 6 inconclusive interventions that did not significantly reduce anthropometric measures were also multicomponent, which included nutrition, PA, media use, sleep and parent involvement. The authors concluded that obesity outcomes can be targeted in low socioeconomic settings through school interventions with a multicomponent approach (nutrition and PA) and the inclusion of parents, but that further research is needed regarding appropriate interventions.
Mansfield and Savaiano, 2017 (43)	1.1, 4.1	This systematic review of 31 studies of the United States National School Lunch Program nutrition standards under three different legislative eras concluded that increasing access to healthy foods during school lunch improved students' dietary intakes.	The review included 31 studies (intervention studies, longitudinal observation studies, one-time observation studies) published between 2007 and 2016.	School lunch changes as result of three sequential federal policies: 1) school wellness policies (implemented 2006–2007); 2) the Healthy, Hunger-Free Kids Act (passed 2010–2012); and 3) the Healthy, Hunger-Free Kids Act (implemented 2012–present).	Children and adolescents aged 5–18 years in schools in the United States.	Of the 19 intervention and longitudinal observation studies, 14 reported improved food consumption behaviours (e.g. increased selection, intake and sales of healthy foods, and decreased plate waste). Only 2 of 12 one-time observation studies reported food consumption behaviours meeting target nutrition standards.

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Mayne, Auchincloss and Michael, 2015 (39)	1.1, 4.1	This systematic review of 37 studies evaluating the efficacy of policy and built environment changes on obesity-related outcomes found improvements in purchasing or self-reported diet from regulations that required improvements to the food environment.	The review included 37 studies of natural or quasi-experimental design, published between 2005 and 2014.	Interventions included introduction of policies (defined as municipal or federal government regulations and laws including school district policies) or change to the built environment that could affect PA, diet or obesity. The 5 school-based nutrition policies concerned restrictions on sugary foods and beverages or higher fat foods, and increases in availability of milk or F&V.	Adults and children in any setting, largely in the United States as well as in Australia, the United Kingdom, Canada, Chile, and New Zealand.	Overall, the majority of studies evaluating regulations that required improvements to the food environment found improvements in purchasing or self-reported diet, while studies that simply required the posting of nutritional information found little effect, with a few exceptions. Of the 5 school-based nutrition-related policies, 4 had results in the expected directions (e.g. reducing energy density, low nutrient dense food, SSBs, calories or fat, or increasing F&V) and 1 had mixed results. Only 1 of the 5 school policy studies measured BMI and reported mixed results.

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Mclsaac et al., 2019 (86)	1.2, 1.3, 1.4, 1.5	This scoping review of 59 studies identified facilitators and barriers to the implementation of school nutrition policies and derived a set of opportunities for action to make such policies more successful.	The review included 59 studies (24 qualitative, 18 quantitative, 9 mixed methods, 8 review studies) published between 2004 and 2017.	Various nutrition strategies (nutrition standards, wellness and health promotion, healthy canteen and snacks, nutrition education) across multiple jurisdictional levels, including national level (19 studies), state or provincial level (30 studies), district, community or local level (5 studies) and multilevel (2 studies); 3 studies did not report level.	Children and adolescents in elementary/primary school (13 studies), junior/middle school (5 studies), high/secondary school (7 studies), multiple school levels, and staff or other stakeholders (32 studies). Most studies were conducted in the United States and other HIC.	Across the final studies identified, factors emerged as facilitators (or barriers in the case of lack of such) to the implementation of school nutrition policies, with system implications related to five areas to support policy action. Opportunities for action were, first, to provide macro-level support to encourage policy implementation. This was analysed in 41 studies in terms of clarity of policy execution and policy language, training support and resources for school staff, monitoring and enforcement of the policies and communication between schools, policy-makers and other stakeholders. The second opportunity identified was to address the financial implications of healthy food access, and this was included in 39 studies in terms of access to and procurement of fruit and vegetables and other nutritious options that often have higher costs but generate more revenue and higher profit. This can lead to trade-offs between keeping costs low for students and families and generating sufficient income from cafeterias and canteens, while also eliminating historic practices in schools of using unhealthy foods to raise funds. Third, aligning nutrition and core school priorities was identified as an opportunity for action; this was examined in 20 studies in terms of competing priorities and demands on, for example, academic assessment that make it difficult for schools to implement nutrition-related changes and the time-consuming nature of policy implementation and partner involvement.

AUTHOR, YEAR	NFS ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Mead et al., 2017 (63)	1.1	This Cochrane review and meta-analysis of 70 studies of behaviour-changing interventions focusing on diet and PA for the treatment of overweight or obesity found that such interventions may be beneficial in achieving small, short-term reductions in BMI, BMI z-score and weight.	The review included 70 RCTs published between 1984 and 2016.	Behaviour change interventions (e.g. education, counselling, healthy food choices, environmental control) focusing on diet (2 studies), PA (6 studies) or both (64 studies).	Overweight, obese or severely obese children aged 6–11 years in the United States, Europe, Australia, New Zealand, Brazil, Canada, Hong Kong, Japan, Malaysia and Mexico. Studies were conducted in multiple settings (school, community, home, primary and secondary care, research clinics); 4 out of 70 studies were conducted in the school setting.	Fourth, developing a common purpose and responsibility among stakeholders, which was included in 45 studies in terms of school climate, values, opinions and cultural norms related to food within schools, at home or in the communities. These cultural norms included the perceived student preference for less healthy foods, the school capacity for leadership and coordination and engagement of parents. A fifth area of opportunity was recognition of school and community characteristics, which was examined in 33 studies in terms of contextualising the policies to school location and demographics, addressing issues of poverty and food insecurity that may lead to inequity, school infrastructure (such as cafeterias or gardens), wider infrastructure and the access to competitive foods from the school surroundings or at home.
						The behaviour change interventions significantly reduced BMI (-0.53 kg/m <sup>2</sup> ; 95% CI: 0.82, -0.24; 2785 participants; 24 trials), BMI z-score (-0.06 units; 95% CI: -0.10, -0.02; 4019 participants; 37 trials) and weight (-1.45 kg; 95% CI: -1.88, -1.02; 1774 participants; 17 trials), but quality of evidence was graded as low. No differences were observed in subgroup analyses on intervention type or setting; however, in subgroup analyses based on setting, the two school based studies included in the meta-analyses did not show significant effect on BMI (-0.57kg/m <sup>2</sup> ; 95% CI: -4.94, 3.80; 21 participants; 1 trial), BMI z-score (-0.01; 95% CI: -0.17, 0.15; 76 participants; 2 trials) or weight (-1.20 kg; 95% CI: -4.20, 1.80; 55 participants; 1 trial).

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Meiklejohn, Ryan and Palermo, 2016 (74)	1.1, 2.2, 3.1	This systematic review of school-based multi-strategy nutrition education interventions found that parental involvement and facilitation of nutrition education by classroom or home economics teachers were the components that most often improved BMI and dietary intake.	The review included 11 RCT studies reported in 13 papers published between 2000 and 2014.	Nutrition education interventions to address consumption of F&V, water, fish, SSB, fat, fibre or sucrose were implemented as part of multicomponent strategies. Components included parental involvement, facilitation of nutrition education by classroom or home economics teachers or other school staff, theory-based instructional strategies, incorporating policy changes within school settings (canteens, food supply and vending machines) and combining nutrition education with PA programmes.	Children and adolescents aged 10–18 years in secondary schools in HIC, mostly in Europe and a few in Australia and United States	Of the 11 studies, 10 reported significant changes in anthropometric measures (weight, BMI, BMI z-score, skinfolds, waist circumference or percent body fat) or dietary intake (F&V, snack foods, fats, sugar, SSB). The multi-strategy nutrition education intervention components that most often improved anthropometrics or dietary consumption in this age group were parental involvement (component in all 4 studies with beneficial effect on BMI and 8 out of 9 studies with beneficial effect on dietary intake) and facilitation of nutrition education by classroom or home economics teachers or other school staff (component in 3 out of 4 studies with beneficial effect on BMI and all 9 studies with beneficial effect on dietary intake). Other contributing factors were theory-based instructional strategies, incorporating policy changes within school settings (changes in canteens, food supply and vending machines) and combining nutrition education with PA programmes.
Micha et al., 2018 (36)	1.1, 4.1	This systematic review and meta-analysis of 91 studies on the effect of school food environment policies found improved targeted dietary behaviours in children but inconclusive effect on adiposity and metabolic measures.	The review included 91 school food environment policy interventions including 39 randomized and 52 quasi-experimental studies, published between 1991 and 2016.	School food environment policy interventions focusing on direct or indirect provision of healthful foods and beverages (40 studies of F&V schemes, water fountains, increased availability of healthy foods at vending machines, etc.), competitive food and beverage nutritional quality standards (29 studies of restrictive policies on SSBs and unhealthy snacks, or based on nutrients, calories or portion sizes) and/or school meal nutrition quality standards (39 studies of school lunch or breakfast standards).	Children and adolescents in preschool (1 study), primary (47 studies) or secondary (27) school and one at multiple levels, mostly in the United States, Canada, New Zealand and Europe, but also Republic of Korea and Iran.	Direct or indirect provision policies, which largely targeted F&V, increased consumption of fruits (0.27 servings/d; 95% CI: 0.17, 0.36; 15 estimates), F&V (0.28 servings/d; 95% CI: 0.17, 0.40; 16 estimates) and vegetables (0.04 servings/d; 95% CI: -0.01, 0.08; 11 estimates). Other meta-analyses found no effect on total calories intake, water consumption, or any adiposity and metabolic measures from the provision policies. Competitive food and beverage standards reduced total consumption of SSBs (-0.18 servings/d; 95% CI: -0.31, -0.05; 2 estimates) and unhealthy snacks (-0.17 servings/d; 95% CI: -0.22, -0.13; 2 estimates) as well as in-school consumption of unhealthy snacks (-0.05 servings/d; 95% CI: -0.08, -0.02; 9 estimates). Other meta-analyses found no effect on in-school SSB consumption, total calories intake, or overweight/obesity from competitive food and beverage standards.



AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Murimi et al., 2018 (102)	2.2, 2.3, 3.1	This systematic review of 41 school- or preschool-based nutrition education studies identified the characteristics of successful interventions as those with a multicomponent approach that were age appropriate and of adequate duration, that actively engaged parents, and that ensured fidelity and proper alignment between the stated objectives, the intervention and the desired outcomes.	The review included 41 studies (cluster RCTs, RCTs, quasi-experimental, pre- and post-test design, longitudinal, study with intervention and control, randomized, multiyear intervention) published between 2009 and 2016.	Nutrition education interventions, with or without additional programme components.	Children and adolescents in preschool (7 studies), primary school (26 studies) and secondary school (8 studies) worldwide, with about a quarter of the studies from the United States.	School meal standards (mainly lunch) increased fruit intake (0.76 servings/d; 95% CI: 0.37, 1.16; 2 estimates), reduced intake of total fat (-1.49% E; 95% CI: -2.42, -0.57; 6 estimates) and saturated fat (-0.93% E; 95% CI: -1.15, -0.70; 4 estimates), reduced sodium intake (-170 mg/d; 95% CI: -242, -98; 4 estimates) and reduced BMI percentile (-1.01; 95% CI: -1.62, -0.39; 2 estimates). Positive effects were also seen on increased milk consumption and carbohydrate intake in studies of policies targeting these elements. Other meta-analyses found no effect on total calories, dietary fibre, whole grains, or other adiposity and metabolic measures.

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Muzaffar, Metcalfe and Fiese, 2018 (125)	3.1.3.3	This narrative review of 6 school-based hands-on culinary skill interventions identified too few studies to draw conclusive findings but noted substantial qualitative effect size in individual studies on dietary behaviour and other outcomes.	The review included 1 RCT and 5 quasi-experimental studies published between 1998 and 2013.	School-based hands-on culinary skill interventions, combined with nutrition education lessons (2 studies), parent and community components (3 studies), gardening classes (2 studies), tasting sessions (2 studies), school lunchroom components (1 study), trips to a farmer's market (1 study) or visits to a restaurant (1 study).	Children aged 5–12 years in schools in the United States, Australia and the United Kingdom.	Parent involvement was particularly important in the preschool setting. Age-appropriate and experiential activities were also associated with successful studies (e.g. hands-on learning, cooking or tasting session, play and games on topics important to the age group). Furthermore, studies that had high fidelity (i.e. that intervention activities are executed as planned in the methods) and that trained existing teachers or engaged nutrition and PA experts in the implementation were more likely to succeed. Finally, successful nutrition education interventions had clear alignment between the stated objectives, the desired outcome and the implemented activities.
						All 6 studies were successful in meeting their objectives. Quantitative analysis available from 3 studies indicated improvement in food preferences, cooking skills, cooking self-efficacy, cooking behavioural intentions, food-preparation frequency, knowledge, healthy dietary intake, BMI and blood pressure. Qualitative evaluations available from all 6 studies indicated substantial effect in terms of programme appeal and improvement in cooking skills and healthy eating.

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Nathan et al, 2019 (97)	2.2, 4.1	This systematic review and meta-analysis of 10 school- or centre-based studies found some evidence that lunchbox interventions are effective in improving children's lunchboxes, particularly the inclusion of vegetables.	The review included 10 studies (8 RCTs and 2 quasi-experimental designs) published in 13 papers between 2008 and 2016.	Interventions to increase parent knowledge via delivery modes such as pamphlets, newsletters, posters or parent workshops. All 10 trials were multicompartment interventions; 8 also included an education component for children, 4 provided physical resources (e.g. lunch packs, containers) and 2 provided incentives for children to taste vegetables and fruit. Two centre-based studies incorporated the development of a policy and the communication of this to parents. Seven studies were stand-alone lunchbox interventions and 3 were part of larger child obesity prevention programmes.	Children aged 3–14 years in child care centres (4 studies) and schools (6 studies) in the United States, the United Kingdom, Australia, Mexico and Israel.	Meta-analysis of 4 studies (2 in schools and 2 in centres) found a moderate increase in provision of vegetables (SMD: 0.40; 95% CI: 0.16, 0.64; P=0.001) but not fruit. Sub-analyses by setting revealed that a significant increase remained in centre-based studies, but not in school-based studies. Of the other 4 studies measuring this outcome but not included in the meta-analysis, 2 centre-based and 1 school-based studies reported significant effects whereas one school-based study reported no significant effect. Of the 4 studies measuring inclusion of discretionary foods (i.e. energy-dense, nutrient-poor food items such as snacks and confectionary), 1 centre-based study reported positive effects, 1 centre-based study reported no effect and 2 school-based studies had mixed results. Of the 3 studies measuring inclusion of SSBs, 1 centre-based study reported positive effects whereas 2 school-based studies reported non-significant effect. Of 3 studies measuring the contents of children's lunchboxes, 1 centre-based study reported no effect, while 2 school-based studies reported significant effects. Of 3 studies measuring children's dietary intake of F&V, 2 school-based study reported a significantly higher mean consumption of fruit, vegetables and/or juice, whereas 1 other school-based studies had mixed results. One school-based study measuring consumption of foods high in fat or sugars found no intervention effect. Two multicompartment studies conducted in a centre and school respectively, reported effects on weight related outcomes. While all included studies in the review incorporated a parent component, many simply relied on passive information dissemination strategies.

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Nekitsing et al., 2018 (115)	3.1.4.1, 4.2	This meta-analysis of 30 studies aiming to increase vegetable intake in children aged 2–5 years, 24 of which were conducted in preschool or child care settings, found the largest effect from repeated taste exposure.	The review included 30 studies of various designs (4 RCT, 8 cluster RCT, 6 crossover, 6 between-subjects, 3 within-subjects, and 3 pre- and post-test design) published between 2011 and 2015.	Interventions to increase vegetable consumption in preschool age children through educational interventions, repeated taste exposure, pairing, changed food-services, explicit reward, modelling, choice, variety and visual presentation.	Children aged 2–5 years, largely in the preschool or child care setting, largely in the United States and Europe, as well as in Australia, Mexico and Thailand.	In the overall meta-analysis of Hedges <i>g</i> , a small-moderate effect ( $g=0.40$ ) of intervention was observed from pooling results of 30 studies and a slightly higher effect ( $g=0.42$ ; 95% CI: 0.33, 0.51; $P<0.001$ ) from pooling results of all 44 intervention arms. In subgroup analyses of intervention strategies, the studies using taste exposure had a significantly higher impact on intake ( $g=0.79$ ; 95% CI: 0.53, 1.05) than food service ( $g=0.30$ ; 95% CI: 0.10, 0.50) or educational ( $g=0.30$ ; 95% CI: 0.15, 0.46) strategies alone, especially when coupled with reward and modelling in studies ( $g=1.08$ ; 95% CI: 0.50, 1.66) with largest effect size for unfamiliar or disliked vegetables. Heterogeneity remained high in both the main and the subgroup analyses.
Niebyski et al., 2014 (157)	4.1	This systematic review of 34 studies of food procurement policies, 19 of which were implemented in the school setting, found that nearly all of these demonstrated positive changes in healthy food purchasing patterns.	The review included 34 studies. Studies were included if they were RCTs, prospective and retrospective non-randomized food procurement interventions.	Healthy food procurement policies such as regulations, standards and guidelines increasing the availability of healthy and/or decreasing the availability of unhealthy foods and beverages served or sold in schools.	All populations. Out of 34 studies, 19 took place in a school setting, while others took place at work sites, hospitals, correctional facilities, government facilities, etc. and were primarily in the United States, United Kingdom and Canada.	All of the food procurement interventions in school settings demonstrated increases in healthy food purchasing patterns. Many of the school interventions that also included an education component were effective at increasing the intake of healthy foods and decreasing the intake of foods high in fat, sodium and sugar. Two studies that assessed health outcomes found a reduction in blood pressure and BMI. In these studies, procurement of food involved providing greater quantities and lowering the price of healthy foods in cafeterias and vending machines.

NFSI ESSENTIAL CRITERIA		STUDY SETTING AND POPULATION			RESULTS OF REVIEW	
AUTHOR, YEAR	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	POPULATION	RESULTS OF REVIEW	
Niemeier, Hektner and Enger, 2012 (87)	2.2 This systematic review and meta-analysis in multiple settings suggests that interventions that require parent participation more effectively reduce BMI in children and adolescents.	The review included 36 RCT studies of a total of 42 interventions, published between 2005 and 2010.	Nutrition education (classroom lectures or interactive workshops), PA education (discussions and educational materials), PA sessions (play, skills development), behaviour education or therapy (sessions or individual counselling to foster self-control and self-efficacy to improve dietary, PA or sedentary activity habits) or a combination of these activities. Seventeen interventions were preventive interventions, while 25 were treatment interventions. Parent participation (e.g. lessons, complementary sessions, handbooks, counselling, meetings) was required in 23 studies, optional in 9 studies and not included in 10 studies.	Children and adolescents aged 2–19 years (n=7455), globally. The preventive studies consisted of >90% of total sample, and the majority of these studies were school-based.	Interventions that required parent participation had greater success than interventions with no parent participation (weighted average differences in effect sizes 0.30; $P=0.027$ ) and with no or optional parent participation ( $P=0.016$ ). This suggests that weight-related health interventions that require parent participation more effectively reduce (or increase less) the BMI of children and adolescents. Moreover, significant differences existed among levels of parent participation ( $P<0.05$ ) and intervention duration ( $P=0.006$ ), and the linear combination of parent participation and intervention duration significantly predicted intervention effectiveness ( $P=0.001$ ).	
Nixon et al., 2012 (99)	2.2, 3.3, 4.11 This systematic review of 12 obesity prevention studies among children aged 4–6 years in the school setting highlighted that parental involvement results in a higher rate of success.	The review included 12 individual studies published between 1998 and 2010. Three were non-randomized controlled trials and 9 were RCTs (of which 5 were cluster-RCTs).	All interventions were aimed at preventing obesity by increasing PA and healthy eating and reducing sedentary behaviour including education, PA, modelling behaviour by teachers and parents and environmental changes — with different levels of parental involvement.	Children aged 4–6 years in preschools and schools in Europe, North America, Asia and Australia.	Parental involvement was high in 3 out of 4 studies reporting favourable outcomes in weight status and in all 5 studies reporting favourable dietary behaviour outcomes. Interventions with the highest success had a high level of parental involvement and the following: 1) Developing skills and behavioural capability; 2) Developing self-efficacy; 3) Educating parents and children (in classroom-based and/or practical sessions) about the benefits of healthful dietary and PA behaviours; and 4) Modelling healthful eating and PA by parents and/or teachers. The authors also noted children's (and parents') perceived competence in making healthy changes in their diet and PA levels as a key element for success.	

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Nørnberg et al., 2016 (153)	4.1	This systematic review of 12 studies found inconclusive evidence on the effect of choice architectural nudge interventions promoting vegetable consumption among adolescents; however, the interventions that seemed most likely to succeed in increasing vegetable consumption were those where the variety offered was increased.	The review included 12 studies of different design (RCT, experimental, quasi-experimental, pre- and post-test design, cohort) published between 2001 and 2013.	Choice architectural nudging interventions influencing choice without limiting choice sets or making alternatives costlier. The specific interventions to influence adolescent's vegetable intake included 1) distribution of free vegetables; 2) modifications to serving style; and 3) changing the physical environment.	Adolescents aged 11–19 years in the school setting in the United States, Canada and Denmark.	The review found inconclusive evidence from the 12 studies on the effect of choice architectural nudge interventions on promoting vegetable intake among adolescents in schools. The authors concluded that providing free vegetables resulted in more favourable attitudes towards vegetable consumption and that offering a greater variety of vegetables resulted in an increase in vegetable consumption.
Oosterhoff et al., 2016 (89)	2.2	This systematic review and meta-analysis of 85 RCTs showed that school-based lifestyle interventions may result in beneficial changes in children's BMI and blood pressure; parental involvement accentuated these beneficial effects.	The review included 91 papers, published between 1985 and 2013, of 85 unique RCTs in which the control group did not receive any intervention beyond usual curricular activities.	Interventions aimed at improving diet (e.g. by changes in foods provided by school canteens/cafeterias), PA (e.g. increasing physical education or activity during or after school hours, reducing sedentary behaviour) or education for healthier dietary and activity behaviours (e.g. through pamphlets, didactic materials and/or lectures). Of the 85 RCTs, 53 also included a parental involvement component (e.g. by newsletters, information sessions, via homework tasks for children) and 19 included after-school hours activities.	Children aged 4–11 years in the primary school setting in 29 different countries. Most studies were conducted in Europe (37 studies) and North America (33 studies), whereas some were conducted in Oceania (7 studies), Asia (5 studies), South America (2 studies) and North Africa (1 studies).	Univariate multilevel analyses of study outcomes showed significant beneficial pooled effect sizes in BMI (-0.072; 95%CI: -0.106, -0.038), SBP (-0.183; 95%CI: -0.288; -0.078) and DBP (-0.071; 95%CI: -0.185, 0.044). Using a magnitude of SDs around the BMI mean values (on average 3.1 kg/m <sup>2</sup> ). The authors noted that the reduction in BMI translated to approximately -0.22 kg/m <sup>2</sup> . For blood pressure, the larger effects were seen for children who already had high baseline values, whereas for BMI the effects applied to all regardless of baseline weight status. Multivariable meta-regression analyses of study population, interventions and study quality characteristics as moderators showed that parental involvement significantly improved the beneficial effects on BMI and SBP ( <i>P</i> <0.05).

NFSI ESSENTIAL CRITERIA		ONE SENTENCE SUMMARY		STUDY TYPES		STUDY INTERVENTIONS		STUDY SETTING AND POPULATION		RESULTS OF REVIEW	
Peirson et al., 2015 (48)	1.1.3.2	This systematic review and meta-analysis of 90 studies of behavioural obesity prevention interventions, of which 71 were school-based, showed small reductions in BMI, but no intervention strategy consistently produced benefits.	The review included 90 studies of RCTs published between 1998 and 2013. The review was designed as an update of the Waters et al. (2011) Cochrane review and included 28 of those studies.	Behaviour change interventions focusing in diet (16 studies), PA (20 studies), diet and PA (32 studies) or lifestyle (22 studies). Most school-based interventions focused on nutrition education/messages, although other approaches were also included (e.g. altering food environment, providing sugar-free beverages, counselling by school health nurses, parent involvement).	Children and adolescents aged 0–5 years (21 studies), 6–12 years (53 studies) and 13–18 years (17 studies), largely in school settings (71 studies), mostly in the United States and Europe, but also in Canada, Australia, Brazil, Israel, China, Egypt, India, Mexico, New Zealand and Thailand.	The overall meta-analysis of 76 studies involving 56 342 children in all settings showed small but significant reductions in BMI or BMI z-score (SMD: -0.07; 95% CI: -0.10, -0.03; 76 studies), in BMI (MD: -0.09 kg/m <sup>2</sup> ; 95% CI: -0.16, -0.03; 56 studies), and in overweight and obesity prevalence (RR: 0.94; 95% CI: 0.89, 0.99; 30 studies). In various subgroup analyses, differences in effect were only seen for different settings (P=0.04), where only the education setting significantly reduced BMI or BMI z-score (SMD: -0.09; 95% CI: -0.17, -0.03; 51 studies; 47 975 participants). For other subgroup analyses, the only subgroups with significant reductions in BMI and BMI z-score were for interventions of diet and exercise combined (SMD: -0.10; 95% CI: -0.17, -0.03; 26 studies; 14 923 participants), and for the age groups 6–12 years (SMD: -0.06; 95% CI: -0.10, -0.01; 42 studies; 36 916 participants) and 13–18 years (SMD: -0.12; 95% CI: -0.22, -0.02; 17 studies; 12 496 participants).					
Peralta, Dudley and Cotton, 2016 (720)	3.1	This scoping review of studies of 32 nutrition education resources found that such resources are less likely to embed cross-curricular and experiential learning approaches or contingent reinforcement approaches.	The review included studies of 32 nutrition resources published in 49 papers between 1980 and 2014.	The teaching strategies for healthy eating/nutrition mostly included curriculum approaches (32 resources), cross-curricular approaches (13 resources), parental involvement (15 resources), experiential learning approaches (7 resources); contingent reinforcement approaches (2 resources), literary abstraction approaches (22 resources), games-based approaches (13 resources) and web-based approaches (10 resources).	Primary school age children, in school settings largely in the United States and Australia as well as the United Kingdom and New Zealand.	The scoping review found that most nutrition education resources include curriculum-based aspects, delivered in and outside the classrooms, through online, or web-based learning. However, the resources were less likely to embed cross-curricular, experiential learning approaches and contingent reinforcement activities.					

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Price et al., 2017 (179)	3.1	This systematic review of 9 studies on nutrition education and BMI suggested that long-term nutrition education delivered in the school setting can provide children with tools to attain a healthy weight status.	The review included 9 studies (RCT, non-randomized controlled trials, quasi-experimental, secondary data analysis) published between 2008 and 2015.	Nutrition education following a school curriculum pattern of teacher-led lecture and follow-up activities, such as a regular classroom lesson, by trained teachers. All the interventions utilized a programme previously developed by a United States government and/or professional organization.	Children in kindergarten through grade 5 (7 studies) and grades 6–8 (2 studies) in the school setting in the United States.	Four of the 7 studies on nutrition education delivered to the younger children demonstrated a statistically significant decrease in the measured BMI percentile, primarily a decrease in the overweight/obese categories in the participants, whereas 1 of the 2 studies in the older children demonstrated a decrease in the highest class of obesity (>95 percentile). In both groups, interventions with long-term (greater than 1 year) implementation showed more pronounced results with positive impact on reducing overweight/obese BMI measures.
Robinson-O'Brien, Story and Heim, 2009 (123)	3.1, 3.3	This review suggests that garden-based nutrition education programmes may have potential to promote increased F&V intake among youth and increased willingness to taste F&V among younger children; however, empirical evidence in this area is relatively scant.	Eleven studies were included, of which 5 were pre- and post-test with intervention and control or comparison groups, 5 were pre- and post-tests within the same population and 1 study reported themes from focus groups. Studies were published between 1999 and 2007.	Garden-based youth nutrition intervention programmes with or without nutrition education component.	Children and adolescents aged 5–15 years in the United States. Five of 11 studies were located on school grounds and were integrated within the school curriculum, 3 were conducted as part of an after-school programme and 3 were community-based.	Of the 8 school or after-school based studies, 2 out of 3 studies measuring F&V intake reported significant increases as result of exposure to garden-based nutrition education, 2 out of 5 studies measuring willingness to try vegetables reported improvements, 3 out of 3 studies reporting on willingness to taste vegetables reported improvements, and 3 out of 5 measuring nutrition knowledge reported improvements.



NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
<p><b>AUTHOR, YEAR</b> Ruggieri and Bass, 2015 (176)</p>	<p><b>5.1.5.2</b> This comprehensive review of 24 studies found that despite the controversies surrounding school-based BMI screening programmes, they can be valuable for students, parents and schools as part of school-based obesity prevention programmes and promotion of healthy lifestyles in schools.</p>	<p>The review included 24 papers/reports evaluating mandatory BMI screening programmes in the United States between 2005 and 2012. Related legislation and other literature were also included.</p>	<p>Mandatory school-based BMI screening and surveillance programmes outlined in United States state legislation and policies.</p>	<p>School-aged children (age not specified) in 7 US states in the school setting.</p>	<p>Confidentiality is a primary concern of BMI screening programmes, shared by parents, school nurses and school administrators. However, most parents support such programmes provided respect for student privacy is maintained at all levels. Resources required for staff, measurement tools, obtaining parental permission and reporting data were reduced by introducing biennial rather than annual screening. BMI screening and referrals led to increased follow-up action by parents in some studies, whereas other studies reported that only a small percentage of parents actually did so. Other reported outcomes were reduced use of diet-pills, encouraging a healthy breakfast, limiting family consumption of unhealthy foods and beverages, decreasing family meals in fast food restaurants, limiting unhealthy fats for meals cooked at home, limiting children's screen time, giving more time for PA, and reducing the use of PA as punishment. One study reported stabilization of BMI over the years of the programme.</p>
<p><b>AUTHOR, YEAR</b> Sacco et al., 2017 (159)</p>	<p><b>4.2</b> This systematic review of menu labelling on foods and beverages chosen by children or adolescents found that such labelling measures may be understood and used by children, including in school cafeterias.</p>	<p>The review included 11 studies published between 2005 and 2015 describing primary research on menu labelling and of multiple research designs (prospective cohort design, repeat cross-sectional pre- and post-test designs, RCTs, within-participant experimental design).</p>	<p>Interventions included both real-world menu labelling which led to actual food purchases (6 studies) and in artificial settings where menu labelling led to hypothetical food purchases (5 studies). Children were ordering for themselves (7 studies) or parents were choosing on behalf of their children (5 studies). Menu labelling included numeric calorie or nutrient content information with or without DBI, interpretative information to illustrate (e.g. healthier choice or symbols).</p>	<p>Children aged 6–18 years and parents. Of 11 studies, 3 took place in a middle or high school setting while others took place in real-life restaurant settings or hypothetical situations.</p>	<p>The studies of hypothetical food purchases in artificial environments suggest that menu labelling may be efficacious in reducing calories purchased for or by children and adolescents. The real-world studies were less supportive, although 2 of 3 school-based studies suggested a potential impact of fat or energy content of purchase, for example, as a result of menu or calorie labelling in the school cafeteria.</p>

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Salam et al., 2016 (183)	5.3	This systematic review and meta-analysis of 31 school-based, found that school-based micronutrient supplementation can significantly reduce anaemia prevalence in adolescents, especially in girls.	For the review of micronutrient supplementation to adolescents, a total of 31 studies were included, of which 16 were RCTs, 7 were quasi-experimental and 8 were before-after. Studies were published between 1996 and 2012.	Studies evaluated the effectiveness of iron, folic acid, vitamin A, vitamin D, vitamin C, calcium, zinc and MMN supplementation to adolescent populations. Thirteen studies evaluated the impact of iron/iron folic acid supplementation alone, 9 studies evaluated the impact of iron/iron folic acid in combination with other micronutrients, 2 studies evaluated the impact of MMN alone, 2 studies evaluated zinc supplementation while 5 studies supplemented with calcium and vitamin D.	Adolescent girls (all 31 studies) and boys (9 studies) primarily in low- and middle-income countries. Twenty-six studies were conducted in the school setting and 5 were community-based.	Findings suggest that micronutrient supplementation among adolescents (predominantly females) can significantly decrease anaemia prevalence (RR: 0.69; 95% CI: 0.62, 0.76). Subgroup analysis suggested that school-based delivery significantly reduced anaemia (RR: 0.67; 95% CI: 0.60, 0.74) while evidence from community-based delivery was underpowered. School-based delivery of iron/iron folic acid supplementation alone or in combination with other micronutrient supplementation was also associated with improved serum haemoglobin (MD: 1.94 g/dl; 95% CI: 1.48, 2.41), ferritin (MD: 3.80 mcg/L; 95% CI: 2.00, 5.59) and iron (MD: 6.97 mmol/L; 95% CI: 0.19, 13.76). Zinc supplementation – also delivered through schools – led to improved serum zinc concentrations (MD: 0.96 mcg/dl; 95% CI: 0.81, 1.12) while calcium and vitamin D supplementation did not have a clear impact on vitamin D levels and parathyroid hormone. Gender-specific subgroup analysis suggests significant improvements in both genders; however, most of the studies were conducted on adolescent girls.

NFSI ESSENTIAL CRITERIA		STUDY SETTING AND POPULATION			RESULTS OF REVIEW	
AUTHOR, YEAR	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	POPULATION	RESULTS OF REVIEW	
Saraf et al., 2012 (103)	2.2 This review found that school-based interventions had mostly positive effects on reducing risk factors of NCDs and that positive results were more likely when interventions included families and communities rather than schools alone.	This review included 37 studies, 30 of which were RCTs and the remaining were non-randomized trials.	NCD risk factor prevention interventions including PA, nutrition and other NCD risk factors. Of the 37 studies, 8 focused on nutrition and 9 focused nutrition and PA or other lifestyle component, about half of these had a community/parent involvement component. Nutrition intervention activities included nutrition education, PA, health and life-skills education, changes in school food environment and parental/family components.	Children and adolescents aged 6–18 years in a school-based setting in the United States, Europe, Australia, China and India.	Overall, 80% of studies reported at least some evidence of a positive intervention effect on various NCD risk factors including diet and PA (e.g. nutrition knowledge, skin fold thickness, SSB consumption, BMI, overweight prevalence, PA levels). The interventions promoting nutrition were more successful if knowledge was the outcome indicator as compared with consumption of F&V. A greater proportion of studies that involved families or communities showed positive results compared to interventions that took place in school settings alone.	
Schroeder, Travers, and Smaldone, 2016 (88)	2.2, 5.3 This systematic review and meta-analysis of 11 school-based obesity interventions involving school health nurses demonstrated small but significant effects on BMI and suggests that nurses can play a key role in implementing effective school-based obesity interventions.	The review included 11 studies published between 2008 and 2015 (4 RCT, 7 quasi-experimental), of which 8 were included in the meta-analysis.	School-based interventions involving nurses in a role beyond anthropometric measurement (e.g. student education and counselling, parent participation in counselling, consultations or education, staff education and PA).	School-aged children and adolescents in the United States, Europe and Asia in the school setting.	The findings showed that school-based interventions that involve nurses led to small but significant decreases in BMI, BMI z-score and BMI percentile. The pooled analyses of 8 studies demonstrated statistically significant decreases in BMI (-0.48; 95% CI: -0.84, -0.12), BMI z-score (-0.10; 95% CI: -0.15, -0.05) and BMI percentile (-0.41; 95% CI: -0.60, -0.21). In subgroup analyses of 6 studies, 3 studies with parent involvement (-0.72; 95% CI: -1.42, -0.01) resulted in larger, though not significant, decreases in BMI than the 3 studies without this component (-0.06; 95% CI: -0.11, -0.01). These results are similar to other meta-analyses of school-based child obesity interventions and the authors suggest that nurses can play a key role in implementing effective and sustainable child obesity interventions in schools.	

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Sildén, 2018 (42)	1.1, 4.1	This systematic review of 26 studies on competitive foods and beverage in schools in the United States, found such products to be pervasive in the schools and that policies to restrict these products could improve calorie intake and BMI.	The review included 26 studies of various designs (cross-sectional designs, quasi-experimental, experimental) published between 2006 and 2017.	Twenty studies addressed the availability of competitive foods and beverages in schools, and 14 studies specifically analysed policies implemented in schools.	Children aged 13–18 years in the school setting in the United States. Results of studies with other age groups (e.g. ages 6–12) were extrapolated for inclusion in the review.	The review found that competitive foods and beverages are pervasive in schools, but evidence was lacking that such products cause overweight or obesity in children. On the other hand, the author noted that there was a positive association between competitive food and beverages policies and weight-related and/or dietary outcomes, and provide examples of several cases where caloric intake and overweight/obesity measures had improved.
Silveira et al., 2011 (107)	2.2, 3.1	This systematic review found evidence of positive effects on anthropometry and of increase in F&V consumption from interventions that were longer than 1 year, introduced into the regular activities of the school, included parental involvement, introduced nutrition education into the regular curriculum, and provided F&V by school food services.	The review included 24 RCTs published between 1998 and 2010.	Most studies included school-based nutrition education for the prevention or reduction of overweight and promotion of F&V consumption, with or without complementary interventions addressing the school environment. Components included classroom activities, parental involvement, school nutrition policy, school food service, educational games, social marketing and environmental changes, individual counselling and internet use.	Children and adolescents aged 5–18 years in school and classroom settings, mainly in Europe and North America, but also in Brazil, China and New Zealand.	There was evidence of positive effects on anthropometry (BMI, BMI z-score) and of increase in F&V consumption. While only 1 out of 9 studies measuring BMI demonstrated improvements in average BMI, most of the interventions with a duration of 1–3 years demonstrated reductions in the prevalence of overweight and obesity with OR ranging from 0.61–0.69. Characteristics of the interventions that demonstrated effectiveness were: duration > 1 year, introduction into the regular activities of the school, parental involvement, introduction of nutrition education into the regular curriculum, and provision of F&V by school food services.

NFSI ESSENTIAL CRITERIA		RESULTS OF REVIEW			
AUTHOR, YEAR	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	
Silveira et al., 2013 (113)	3.1 This systematic review and meta-analysis of 8 studies found evidence that school-based nutrition education interventions are effective in reducing the BMI of children and adolescents, especially interventions of longer duration.	The review included 8 studies of randomized and non-randomized controlled trials and interrupted time series.	School-based nutrition education interventions (e.g. education games, classroom activities) combined with other components (e.g. school nutrition policy, parental involvement, social marketing or environmental changes).	Children and adolescents aged 5–18 years (n=8722) in primary and secondary schools, largely in Europe, but also in the United States and Brazil.	Individually, only 2 studies demonstrated a significant reduction in BMI in children and adolescents in the intervention groups compared with the control groups. The pooled results from 8 studies gave an average effect of $-0.33 \text{ kg/m}^2$ (95% CI: $-0.55, -0.11$ ; $P=0.003$ ) on BMI, with 84% of this effect explained by the highest quality studies. The largest effect on BMI was observed among the 4 studies with a duration greater than one year ( $-0.48 \text{ kg/m}^2$ ; 95% CI: $-0.76, -0.19$ , $P=0.001$ ).
Sobel-Goldberg, Rabinowitz and Gross, 2013 (52)	1.1.2.2 This systematic review and meta-analysis found convincing evidence that school-based obesity prevention interventions are at least mildly effective in reducing BMI, with the largest effects seen in comprehensive programmes longer than 1 year with parental support.	The review included 32 RCT studies published between 2006 and 2012.	School-based obesity prevention programmes designed to reduce BMI in healthy children through changing eating habits, PA and sedentary behaviour. Of the 32 studies, 29 were informative (e.g. information on proper nutrition and PA), 28 behavioural (e.g. daily monitoring and registering of eating patterns and PA), 26 environmental (e.g. making water coolers accessible and organized sports), 19 cognitive (e.g. strategies for attitude and perception change), and 18 had parental support (e.g. parent child events on healthy lifestyle). Thirty of these were multicomponent.	Children and adolescents aged 5–18 years (n=52 109) conducted in school settings mostly in the United States and Europe, but also in Australia, Brazil and China.	School-based obesity prevention programmes resulted in significant reductions in BMI in all age groups (SMD: $-0.076$ ; 95% CI: $-0.123, -0.028$ ; 32 RCTs) and in children alone (SMD: $-0.104$ ; 95% CI: $-0.195, -0.01$ ; 18 RCTs), but gave a non-significant reduction of BMI in adolescents (10 RCTs). Meta-regression showed a significant linear hierarchy of studies based on their design, with the largest effects for comprehensive programmes with parental support (SMD: $-0.151$ ; 95% CI: $-0.334, -0.031$ ; 6 RCTs). Comprehensive programmes included information on nutrition and PA, attitudinal changes, monitoring eating and PA and environmental modifications, and/or aimed to increase PA, decrease sedentary activity, improve healthy eating and decrease unhealthy eating. In performing this review, the authors updated a previous review by Kamath et al. (2008) and noted a remarkable improvement. They suggest that unlike earlier studies, more recent studies showed convincing evidence that school-based prevention interventions are at least mildly effective in reducing BMI in children, possibly because of better programme design and that newer studies tend to be longer, more comprehensive and include parental support.

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Stevens, 2010 (82)	1.1	This literature review of multicomponent obesity prevention programmes in ethnic-minority middle school age adolescents found improved dietary choices and increased F&V consumption.	The review included 8 studies, of which 4 were RCTs, 2 quasi-experimental, 1 longitudinal controlled evaluation study and 1 pre- and post-test design. Studies were published between 1997 and 2007.	Multicomponent interventions for obesity prevention (i.e. both diet and PA). All included nutrition education in addition to other interventions such as parental involvement, food service.	Ethnic minority middle school age adolescents (Hispanic, African American, and Native American) aged 10–14 years in the United States, Australia, Belgium and Chile. Six of 8 studies took place in schools, while 1 study took place in clinics and 1 study took place in a community centre.	The review did not identify any effective interventions specific to ethnic minority children but results across studies showed improvements in dietary outcomes (i.e. decreasing consumption of high fat and other high caloric foods as well as soft drinks and increasing consumption of F&V).
USDA, 2012 (130)	3.1	This systematic review of 24 studies of nutrition education delivered via digital media and/or technology, 15 of which were school-based, found moderate evidence that such interventions may improve dietary behaviour. The review was conducted as part of a series of systematic reviews on various aspects of nutrition education in countries with a high or very high human development index.	The review included 24 studies, 19 RCTs and 5 non-randomized controlled trials, published between 1999 and 2010. Twelve studies received a positive quality rating (12 RCTs), and 12 studies received a neutral quality rating (7 RCTs, 5 non-RCTs).	Computer- or internet-based nutrition education interventions (e.g. multimedia computer games, interactive websites, educational videos, computer story books, advergimes) aiming to change dietary behaviour (e.g. increase intake of F&V, 100% juice, fibre, water, dairy products, breakfast, or decrease intake of fat, calories, soft drinks, fruit drinks (not 100%), sodium, snacks, sweets and sugars).	Children aged 5–16 years in the United States and Europe; 15 of 24 studies were conducted in the school setting.	Moderate evidence was found that nutrition education delivered via digital media/technology (computer- and Internet-based programmes) may be effective for improving dietary intake-related behaviours among children and adolescents; 21 of 24 studies found significant effects on dietary intake-related behaviours in at least one population subgroup, and in 15 of these the intervention was more effective than the control (no-intervention or other delivery method). No pattern emerged related to the delivery setting. The authors concluded that digital media/technology can be delivered to a wide range of children in a variety of settings with high fidelity, with higher likelihood of success from targeting specific behaviours and providing frequent doses over longer periods of time.

AUTHOR, YEAR	NFS ESSENTIAL CRITERIA	ONE-SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
USDA, 2012 (96)	2.2, 3.1	This systematic review of 10 interventions of parental involvement in nutrition education, of which 7 were school-based, found limited and inconsistent evidence that involving parents in nutrition education improves dietary behaviour. The review was conducted as part of a series of systematic reviews on various aspects of nutrition education in countries with a high or very high human development index.	This review included 10 RCTs published between 1995 and 2009. Seven RCTs received a positive quality rating, and 3 received a neutral quality rating.	Strategies to involve parents in nutrition education intervention: direct strategies (e.g. face-to-face sessions), indirect (e.g. newsletters or other educational materials sent home), or a combination of direct and indirect methods).	Children aged 9–18 years in the United States, Europe and Australia; 7 of the 10 studies were school-based.	The authors concluded that limited and inconsistent evidence was available to assess the effects of parental involvement in nutrition education on children's dietary behaviour. Of the 10 studies, 6 found an added benefit from parental involvement improvements in at least one subgroup, of which 3 studies found this effect in girls but not in boys, 2 found improvements in both intervention and control groups, and 2 did not find any effect. One of the 2 studies measuring the effect of increasing dose of parental involvement found a significant dose-response relationship. Studies conducted outside of the United States were more often effective.
USDA, 2012 (132)	3.1, 5.3	This systematic review of the effect of different types of nutrition educators only identified 1 study and concluded that there is insufficient evidence to determine which would be most effective in changing children's dietary intake-related behaviours. The review was conducted as part of a series of systematic reviews on various aspects of nutrition education in countries with a high or very high human development index.	The review included 1 RCT published in 2007.	Nutrition education intervention delivered by two different types of educators.	Children aged 10 years in primary school in Italy.	It was not possible to draw any conclusions because the literature search identified only 1 study. Moreover, the results from this study were mixed, resulting for the most part in no significant differences in dietary intake between the intervention groups. However, increased F&V intake was seen in the teacher group while decreased intake was seen in the nutritionist group. Furthermore, for all food categories, changes in dietary intake were significantly greater in the teacher group compared to the nutritionist group ( $P < 0.0001$ ). The authors noted that the study had several limitations in terms of differences in timing, dose and education format between the groups.

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USDA, 2012 (75)	1.1, 3.1	This systematic review of 5 school-based studies found consistent evidence that combining nutrition education with changes to the school food environment is more effective for improving children's and adolescents' dietary intake than making changes to the food environment alone. The review was conducted as part of a series of systematic reviews on various aspects of nutrition education in countries with a high or very high human development index.	This review included 5 studies (3 RCTs and 2 non-randomized controlled trials) published between 2002 and 2009.	Interventions included combination of nutrition education and changes to the school food environment (e.g. free breakfast provided at school, increased availability and promotion of F&V in the school cafeteria and vending machines, free F&V snack, and increased choice, marketing, and improvement in the preparation and appearance of fish served in the school cafeteria), compared to either one of these alone.	Children with mean age 12–15 years in the school setting in North America and Europe.	Overall, all 5 studies showed that combining nutrition education with changes to the school food environment was effective for improving children and adolescent's dietary intake (e.g. F&V intake, fish consumption), and some evidence suggested that the combination led to greater improvement than either intervention alone. In 2 studies the combined approach was more effective, in 1 study it was more effective in boys only and in 2 studies both approaches were effective.
USDA, 2012 (121)	3.1	This systematic review of 14 studies, 10 of which were school-based, found inconsistent evidence of multi vs. single component nutrition education interventions in improving child and adolescent dietary behaviour, and limited evidence that nutrition education combined with hands-on educational component may be particularly effective. The review was conducted as part of a series of systematic reviews on various aspects of nutrition education in countries with a high or very high human development index.	The review included 14 studies (10 RCTs and 4 non-randomized controlled trials) published between 1996 and 2010.	Nutrition education alone as a single component (e.g. usual classroom education or counselling sessions) or combined with supporting components (e.g. parental involvement, web-based activity, gardening or take home materials).	Children with mean age 7–15 years largely in the United States but also Canada and Europe; 10 of 14 studies were school-based.	There was no agreement on whether multicomponent nutrition education programmes in changing dietary practices than single component programmes and several of the studies had mixed results. In total, 6 studies found multicomponent interventions to be more effective than single component interventions for at least one dietary outcome, 3 studies found single-component nutrition education interventions to be more effective than multicomponent interventions for at least one dietary outcome, and 8 did not find any difference between them. The authors noted that the 3 studies that consistently found better effect of multicomponent interventions were also the only ones to combine nutrition education with a "hands-on" component (e.g. cooking or gardening).



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Van Cauwenberghe et al., 2010 (135)	3.1.4.1	This systematic review of 42 European school-based studies found evidence for the effectiveness of obesity prevention interventions promoting a healthy diet in school-aged children on self-reported dietary behaviour but evidence for effectiveness on anthropometric measures is lacking.	The review included 42 studies (reported in 53 articles including grey literature), of which 13 were RCTs, 16 non-randomized controlled trials, 7 pre- and post-test and 6 prospective cohorts. Studies were published between 1991 and 2008.	Interventions were aimed at the primary prevention of obesity and obesity-related diseases targeting dietary behaviour through education alone in 20 studies (e.g. classroom lessons, educational materials), through environment alone in 8 studies (e.g. increased availability and accessibility of healthy foods, F&V or breakfast subscription or distribution programmes, school lunch modifications) or through a combination of education and environmental measures in 14 studies.	Primary school children aged 6–12 years (29 studies) and adolescents aged 13–18 years (13 studies) in school settings in Europe.	Most studies in both age groups improved dietary behaviour (intake of F&V, fats, soft drinks, water, fish), but only a few studies in the youngest age group improved body composition. In children, strong evidence was found for multicomponent interventions on F&V intakes in children aged 6–12 years but limited evidence was found for educational interventions on behaviour, and for environmental interventions on F&V intakes. In adolescents aged 13–18 years, moderate evidence was found for educational interventions on dietary behaviour and limited evidence for multicomponent programmes on dietary behaviour. In children and adolescents, effects on anthropometric outcomes were often not measured, and therefore evidence was lacking or inconclusive. All five studies on F&V subscription or distribution programmes found effectiveness on F&V intakes; however, only one study showed a lasting effect and therefore evidence that environmental interventions can improve F&V intakes is limited.
Van Lippevelde et al., 2012 (104)	2.2	This systematic review to determine the effect of parental involvement in school-based obesity prevention programmes focused on diet and PA found inconclusive evidence due to the lack of quality studies and inconsistent results.	The review included 5 studies (4 cluster RCTs, 1 RCT) published between 1990 and 2003.	School-based interventions to reduce obesity using educational (e.g. health education, PE, tailored feedback) and environmental (e.g. school food service modifications, more opportunities for PA outside of classes) components.	Children aged 6–18 years in the United States, Australia and Belgium in school settings.	Four out of 5 studies reported positive effects of parental involvement on diverse outcomes (dietary knowledge, health behaviours, BMI, BMI z-score, fat intake). The authors concluded that there is a lack of evidence to support the claim that parental involvement is important to improve effectiveness of school-based behavioural nutrition and PA interventions due to a lack of studies comparing interventions with and without a parental component and due to largely inconsistent results in existing studies.

NFS ESSENTIAL CRITERIA		STUDY INTERVENTIONS			STUDY SETTING AND POPULATION		RESULTS OF REVIEW	
AUTHOR, YEAR	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW	STUDY SETTING AND POPULATION	RESULTS OF REVIEW	
Vargas-Garcia et al., 2017 (177)	3.1. 4.11 The results of this systematic review and meta-analysis of 40 studies, 15 of which were school-based, suggest that school-based interventions may reduce SSB consumption in children.	The review included 50 studies (RCTs, cluster RCTs and non-randomized controlled trials) in the qualitative review, of which 40 studies were included in the meta-analysis.	School interventions were primarily nutrition education (e.g. lessons, homework, printed materials) to reduce obesity or SSB consumption. Five interventions included installation of water fountains or provision of water bottles.	All population groups. Of the 40 studies, 23 had data on children (n=10 964), 5 on adolescents (n=3117) and 12 on adults (n=2424), with one study reporting intakes on both children and adults and another on both adolescents and adults. Countries included Australia, Belgium, Brazil, Canada, Chile, Germany, Malaysia, Mexico, New Zealand, Norway, Portugal, Turkey, the Netherlands, the United Kingdom and United States. Settings of interventions were school-based (15 studies), home (9 studies), community (11 studies) and clinics (5 studies).	Interventions significantly decreased consumption of SSB in children by 76 mL/d (95% CI: -105, -46; 23 studies; $P<0.01$ ) and in adolescents (-66 mL/d; 95% CI: -130, -2; 5 studies; $P=0.04$ ). Pooled estimates of water intakes showed increased consumption in children (MD: +67 mL/d; 95% CI: 6, 128; 7 studies; $P=0.04$ ), but subgroup analysis by setting was not possible. In subgroup analyses of studies with children, significant decreases in SSB consumption were seen for community (-72 mL/d; 95% CI: -115, -30; $P<0.01$ ) and school-based (-28 mL/d; 95% CI: -42, -12; $P<0.01$ ) studies but not for clinical or home-based. For children, there was evidence to suggest that modelling/demonstrating the behaviour helped to reduce SSB intake. Modelling the behaviour was associated with greater effectiveness in reducing SSB after univariate meta-regressions were conducted across all age groups (-124 mL/d; 95% CI: -221, -27; $P=0.01$ ), with similar effects found for studies in children (-173 mL/d; 95% CI: -315, -31; $P=0.02$ ).			
Vasques et al., 2014 (50)	1.1. 2.2. 3.2 This systematic review and meta-analysis on the efficacy of school-based and after-school intervention programmes to address obesity on BMIs of children and adolescents found that parental involvement was a moderator that increased the effect size.	The review included 52 studies of RCTs or non-randomized clinical trials published between 2000 and 2011.	Interventions included PA, diet or lifestyle changes using multiple approaches including education (nutrition education, interactive multimedia, encouragement of PA and health-related sessions), nutrition policy, food service modifications and social marketing. Half of the interventions involved family members or parents (e.g. outreach, education).	Children and adolescents aged 5–18 years (n=28 236) in school or after-school settings. Geographical location was not reported.	The overall effect size on BMI was small for all studies included (0.068; $P<0.001$ ), school-based ( $r=0.069$ ) as well as after-school interventions ( $r=0.065$ ), according to Cohen where the significance of effect sizes is considered small for less than 0.10, medium for less than 0.30, and large for less than 0.50. Programmes combining PA and diet were the most successful with a medium effect size ( $r=0.148$ ), whereas those concentrating only on PA levels were less successful with a small effect size ( $r=0.029$ ). The effect sizes for parental involvement were all small, but increased as the level of parental involvement increased: no involvement ( $r=0.047$ ), minimal involvement ( $r=0.057$ ), moderate involvement ( $r=0.082$ ) and high involvement ( $r=0.094$ ) with significant differences between groups ( $P=0.001$ ).			

NFSI ESSENTIAL CRITERIA		STUDY SETTING AND POPULATION			RESULTS OF REVIEW	
AUTHOR, YEAR	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	POPULATION	RESULTS OF REVIEW	
Velazquez, Black and Potvin Kent, 2017 (167)	4.3 This review of food and beverage marketing in schools found that students are commonly exposed to food and beverage marketing through a variety of strategies, and found numerous instances of non-compliant marketing.	The review included 27 cross-sectional studies (20 unique data sources). More than half (15) of the studies were published between 2010 and 2015, and only two before 2005.	In addition to assessing the exposure to marketing of foods and beverages in schools and presence (or absence) of policies or guidelines regulating food and beverage marketing in schools, two studies evaluated the compliance to existing marketing restriction laws.	Elementary, middle and high schools in the United States, Canada, Ireland and Poland.	The review found that students are commonly exposed to food and beverage marketing through a variety of strategies, especially among high schools and schools with lower socio-economic status. Marketing exposure is often associated with food purchasing and consumption, especially for food items of low nutritional quality (e.g. salty snacks, candy, SSBs). Furthermore, many schools do not have policies or guidelines regulating such marketing. Two studies evaluating the compliance with laws or policies restricting school food and beverage marketing and found numerous instances of non-compliant marketing.	
Verjans-Janssen et al., 2018 (95)	2.2 This systematic review of 25 school-based nutrition and PA interventions with a direct parental involvement component found favourable results on BMI or BMI z-score but mixed results on nutrition behaviour outcomes.	The review included 25 studies of various designs (10 RCTs, 11 quasi-experimental studies, 3 pre- and post-test design, 1 repeated cross-sectional study) published between 1996 and 2018.	Interventions targeted multiple environmental types (e.g. social school and family, physical school, political school environments) addressing nutrition (3 studies), PA (2 studies) or both (20 studies) and were implemented with a direct parent involvement component (e.g. requesting parents to attend education sessions, asking parents to attend or participate in family behaviour counselling or parent training sessions).	Children aged 4–12 years in the school setting, largely in the United States as well as in other countries.	Eleven of 18 studies measuring BMI or BMI z-score found favourable results. Of the 11 studies with favourable results, 6 had small effect sizes (ES -0.04 to -0.27), 2 had moderate effect sizes (ES -0.34 and -0.48) and 1 had a large effect on BMI (ES -0.79). Results regarding nutrition behaviour (e.g. SSB intake, F&V intake, added sugar intake, red meat consumption) were inconclusive, with 5 of 11 studies reporting favourable results and another 5 out of 11 reporting mixed results on outcomes measured. The two interventions targeting only PA and the three interventions targeting only nutrition behaviour were mainly ineffective.	

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Verstraeten et al., 2012 (69)	1.1, 3.1, 3.2	This systematic review of 25 school-based diet and PA interventions in middle- and low-income countries found that most interventions had a positive effect on diet and PA behaviours and BMI and that effective interventions targeted both diet and PA, involved multiple stakeholders, and integrated educational activities into the school curriculum.	The review included 25 studies, primarily cluster-controlled trials with (8 studies) or without randomization (10 studies), presented in 29 publications which were published between 1992 and 2010.	Thirteen interventions involved school staff, communities, parents, children and families and are referred to as multicomponent interventions. Four of the 25 interventions provided an individual counselling component, 4 studies were diet-only interventions (e.g. nutrition education, school breakfast), 10 studies were PA-only interventions (increased physical education), and 11 studies involved both diet and PA.	Children, mean age 6.5 to 18.4 years, in schools, globally but primarily in Latin America (13 studies) and Asia (8 studies). Two-thirds of the studies were conducted in major urban areas (16 studies) and 2 studies included a rural area.	Of the 22 studies reporting useful statistics on the outcomes of interest, 18 had a positive effect on one or more of the outcomes (82%). The 3 diet interventions had significant effect on dietary behaviour (e.g. preferences or consumption of soda, fast food, snacks) (2 out of 3 measuring this), but did not have an effect on any of the BMI-related outcomes. The 9 PA interventions were successful at increasing PA (6 of 7 measuring PA) and lowering BMI in at least one of the studied subgroups (3 of 4 evaluating BMI), but did not have an effect on the prevalence of overweight or obesity (0 of 2 evaluating this outcome). The 10 combined interventions had a significant effect on all outcomes: diet (3 of 3 measuring diet), PA (2 of 2 measuring PA), BMI (5 of 6 in at least one subgroup), and the prevalence of overweight or obesity (3 of 3 evaluating this outcome). Effective interventions targeted both diet and PA, involved multiple stakeholders, and integrated educational activities into the school curriculum with education-based interventions delivered by teachers and providing additional PA sessions or integrated classes about healthy foods, nutrition, or PA to encourage children to adopt a healthy lifestyle.
Vézina-Im et al., 2017 (45)	1.1, 3.1, 4.1	This systematic review of 36 studies on school-based interventions aimed at reducing SSB consumption among adolescents found that most (70%) interventions were effective in decreasing consumption, with the highest success rate (90%) among legislative/environmental approaches.	The review included 36 studies (RCTs, quasi-experimental studies and one-group pre- and post-test studies) published between 1998 and 2015.	Of the 36 studies aimed at reducing SSB consumption, 20 were educational/behavioural (e.g. explaining negative health consequences, behavioural goal setting, written or electronic communication), 10 were legislative/environmental (e.g. banning SSB or replacing SSB with healthier alternatives) and 6 included both components. In most of the studies, reducing SSB consumption was part of a broader goal to improve diet and health.	Children aged 12–17 years (n=152 001) in the school setting. Most were conducted in the United States but also in Canada, Australia, Belgium, Brazil, China, India, Republic of Korea and the Netherlands.	Information was collected on individual SSB consumption including frequency or amount, and comprised of soft drinks, non-100% fruit juices, energy drinks, sports drinks, sweetened tea and coffee, and any other beverages with added sugar. The 10 legislative/environmental studies had the highest success rate (90%), while the 20 educational/behavioural interventions and the 6 interventions that were both educational/behavioural and legislative/environmental had almost equally effective success rates (65% and 66.7%, respectively).

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von Philipsborn et al., 2019 (44)	1.1, 4.1, 4.2, 4.6	This Cochrane review of 58 studies, 20 of which were school-based, found that limiting the availability of SSB in schools (e.g. replacing SSBs with water in school cafeterias) can be effective in reducing SSB intake.	The review included 58 studies (22 RCTs, 3 non-randomized controlled trials, 14 CBA studies and 19 interrupted time series studies) published between 2006 and 2018.	The review included interventions implemented at an environmental level, reporting effects on direct or indirect measures of SSB intake including labelling, nutrition standards in public institutions, economic tools, whole food supply interventions, retail and food service interventions, intersectional approaches and home-based interventions. All the nutrition standards in public institutions interventions were conducted in schools and included reduced availability of SSBs, improved access to drinking water, awarded prizes for the selection of healthier options in school cafeterias, improved placement of healthier beverages in school cafeterias and provided fruits. One labelling intervention concerned the use of emoticons in school cafeterias, and one retail and food service intervention concerned vending machines in workplaces and schools.	The full review considers all age groups in a variety of settings, including schools, retailing and food service establishments. The 20 school-based studies were conducted in elementary, middle and high schools, largely in the United States, but also in Brazil, Germany, Italy, Norway and the Netherlands.	No meta-analysis was performed on the school-based studies. Among the 7 studies on nutrition evidence from 5 studies that reduced availability of SSB in schools is associated with reduced SSB intake; 3 out of 5 studies on largely government policies to reduce the availability of SSBs reported significant effect on total intake of SSB and other beverages excluded by the standard or the share of students consuming SSBs. There was indication that reduced availability of SSB in schools may be increase compensatory SSB consumption outside school among older students but may not affect body dissatisfaction or dieting behaviour. There was also very low-certainty evidence from 4 studies that improved availability of drinking water in schools may be associated with decreased SSB intake; 2 out of 4 studies reported significant effect on total intake of SSB or sugar-sweetened milk and 2 out of 3 that also measured weight-related outcomes reported significant effects. There was indication that improved water availability may decrease total milk selection. There was low- to moderate-certainty evidence from 3 studies that small prizes and token rewards for the selection of plain milk in elementary school cafeterias are associated with decreased selection of sugar-sweetened milk; all of these 3 studies reported significant effect on number of meals with unhealthy beverages selected or chocolate milk purchases.

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Wang and Stewart, 2013 (72)	1.1	This systematic review of 19 nutrition promotion programmes using the HPS approach found that it can improve participants' diets and help develop related healthy behaviours such as hygiene and food safety.	The review included 19 studies published between 1993 and 2011, of which 8 were RCTs, 4 were controlled trials, 6 were pre- and post-test design and 1 was an interrupted time series.	Interventions that used one or more of the HPS framework areas (i.e. school policy, curriculum, family/community involvement). Of the 19 studies, 3 focused on nutrition policy, 6 on nutrition education and 10 used a holistic HPS approach.	Children and adolescents at primary and secondary schools around the world.	There was indication that total milk selection may be affected though the direction of reported effects varied, and that the intervention may be associated with an increase in food waste. There was low-certainty evidence from 1 study that improved placement of plain milk in school cafeterias is not associated with the selection and consumption of sugar-sweetened and plain milk, with no significant effects reported. There was very low-certainty evidence from 2 studies that fruit provision in schools may be associated with decreased SSB consumption by students; both studies reported significant effect. The review also considered other action areas to reduce SSB intake including one study that found positive effect of emoticon (smiley face) labels on plain milk and small prizes in reward for selecting such milk over sugar-sweetened milk (low-certainty evidence). The authors noted that this may drive up food waste if children choose the plain milk but do not drink it. Another analysis concerned the healthier selections in vending machines in workplaces and schools, where the one study in schools reported significant effect on SSB intake. The authors reported that nutrition promotion programmes using a full or partial HPS approach can increase diet and nutrition knowledge, attitude and skills, and behaviour. The authors noted improvements in participants' consumption of high-fibre foods, healthier snacks, water, milk and F&V. It can also reduce participants' "breakfast skipping," reduce consumption of nutrient-poor foods including fatty foods and sweet drinks and reduce eating disorders. Furthermore, these programmes may help to develop hygienic habits and improved food safety behaviours.

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Wang et al., 2013 (58)	1.1, 2.2, 3.2	This comparative effectiveness review and meta-analysis of 124 obesity prevention interventions, of which 104 were school-based, found greater strength of evidence for combined diet and PA interventions than for diet or PA interventions alone.	The review included 124 intervention studies described in 131 articles, consisting of RCTs, quasi-experimental studies and natural experiments.	Interventions including modification of diet, modification of PA or sedentary activity or a combination of these.	Children and adolescents aged 2–18 years in the United States. Of the 124 studies, 104 were school-based.	Over half of the school-based interventions reported statistically significant beneficial intervention effect in at least some weight-related outcomes (BMI, BMI z-score, prevalence of overweight and obesity, waist circumference, skinfold thickness and percent body fat). In the analysis of setting and intervention components, high strength of evidence for the benefits of school-based approaches was found for PA alone with a home component, and combined diet and PA with a home and a community component, while moderate strength of evidence was found for diet alone, PA alone, and combined diet and PA with a home or a community component. The authors noted that despite the large number of studies combining diet and PA interventions in schools, the evidence remains insufficient as result of inconsistency across studies. Only few school-based combined diet and PA studies included sufficient data and homogeneity for meta-analysis: 4 studies showed improved BMI z-score (-0.08; 95% CI: -0.14, -0.02; $P=0.009$ ) whereas 7 studies showed improved BMI (-0.32 kg/m <sup>2</sup> ; 95% CI: -0.49, -0.16; $P<0.001$ ). Another 8 school-based combined diet and PA studies with a home component did not show improved BMI in meta-analyses. Comprehensive interventions addressing the environment (e.g. modified food and beverage items offered in school cafeteria or structural changes in school PA) and individuals' knowledge and attitudes (e.g. nutrition education) were more likely to be successful than those addressing either one alone. Educational interventions were less likely to be effective than environmental changes.

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Wang et al., 2015 (93)	2.2	This systematic review and meta-analysis of 139 obesity prevention studies, 115 of which were school-based, found that there is at least moderate evidence that such programmes reduce BMI, especially multicomponent strategies that include home involvement.	The review included 139 intervention studies published in 147 articles between 1985 and 2014, which included RCTs, quasi-experimental studies and natural experiments.	Studies evaluated combined diet and PA interventions (104 studies), PA only (28 studies) and diet only (7 studies).	Children aged 2–18 years, in HIC, especially the United States. Of the 139 studies (covering <100000 children), 115 were mainly carried out in the school setting and 24 mainly in other settings (home, primary health care facilities, child care or communities).	There was at least moderate evidence to support the effectiveness of school-based interventions. Overall, studies of multiple setting interventions had beneficial and significant results more often than single setting interventions. Statistically significant effects were reported by about half of the school-based studies, especially those with a home involvement component. Meta-analyses were performed when more than 3 comparable studies were available for a given intervention strategy and setting. The pooled results were significant for school-based only interventions for BMI z-score (-0.05; 5 studies; P=0.025) and BMI (MD: -0.3 kg/m <sup>2</sup> ; 9 studies; P<0.001), but insignificant for school-based interventions combining diet and PA with a home component. The pooled effect sizes estimated in these meta-analyses were still small compared to the recent increase in BMI and overweight rates in many countries. The authors concluded that the strength of evidence was high for PA-only interventions delivered in schools with home involvement or combined diet/PA interventions delivered in schools with both home and community components. Strength of evidence was moderate for school-based interventions targeting either diet or PA, combined interventions delivered in schools with home or community components or combined interventions delivered in the community with a school component.



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Wang et al., 2018 (112)	3.1	This systematic review and meta-analysis of 30 studies of educational interventions on health found positive effects on BMI, BMI z-score, waist circumference, triceps skinfold, SBP, total cholesterol, and triglycerides.	The review included 30 RCTs, published between 1989 and 2016.	Health education interventions to prevent obesity, as single or multicomponent intervention with a duration of 6–72 months.	Children (n=35 296), mean age ranged from 2.5 to 11.8 years. Seventeen studies were from Europe, 11 were from America and 2 were multi-country studies. A large majority of studies appear to have been conducted in schools.	Educational interventions on health had significant effects on the weighted mean difference of BMI (-0.15 kg/m <sup>2</sup> ; 95% CI: -0.24, -0.05; P=0.003), BMI z-score (-0.03; 95% CI: -0.05, -0.02; P<0.001), waist circumference (-0.97; 95% CI: -1.95, -0.00; P=0.050), triceps skinfold (-1.39; 95% CI: -2.41, -0.37; P=0.008), SBP (-1.13; 95% CI: -2.20, -0.07; P=0.037), total cholesterol (-4.04; 95% CI: -7.18, -0.90; P=0.012) and triglyceride (-2.62; 95% CI: -4.33, -0.90, P=0.003). However, educational interventions were found to have little or no significant impact on the waist-to-hip ratio, DBP, high-density lipoprotein and low-density lipoprotein.
Ward et al., 2017 (100)	2.2	This systematic review of 43 preschool-based obesity prevention studies found tentative evidence that multicomponent, multi-level interventions with parental engagement are most likely to be effective with anthropometric outcomes.	The review included 43 studies of various designs, including RCTs, non-experimental pre- and post-test design, within subject cross-over and longitudinal follow-ups to RCTs, published between 2010 and 2015.	Interventions included strategies to improve healthy eating (e.g. menu changes, nutrition education, changing meal service approaches, and food tastings) and/or PA, with or without parental involvement (e.g. workshops, cooking classes, newsletters, CDs, handouts).	Children aged 2–6 years in preschools in the United States, Europe, Australia, as well as Chile.	Thirteen of 18 studies including a dietary intake measure and 10 of 24 studies with an anthropometric measure demonstrated at least one successful intervention effect. To investigate the effect of individual intervention elements, an intervention strength was defined using approaches common in community health efforts for obesity (i.e. as a composite of the number of intervention strategies used), their potential impact (high for policy/environment, low for education), and the frequency and duration (higher the more frequent exposures or longer duration) of their use. This strength was positively correlated with reporting of positive anthropometric outcomes for PA, diet and combined interventions. Furthermore, parent engagement components increased the strength of these relationships. Thus, the authors concluded that tentative evidence exists that multicomponent, multi-level interventions with parental engagement were most likely to be effective with anthropometric outcomes.

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Waters et al., 2011 (47)	1.1, 3.2	This review and meta-analysis of 55 programmes to prevent childhood obesity, 43 of which were school-based, found strong evidence to support beneficial effects of child obesity prevention programmes on BMI, particularly for programmes targeted at children aged 6–12 years.	The review included 55 studies that used a controlled study design (with or without randomization), 37 of which were included in the meta-analysis. The studies were published between 1993 and 2009.	Interventions or programmes that involved diet and nutrition, exercise and PA, lifestyle and social support. Nutrition interventions were largely behavioural, focusing on curriculum or education/messages, although some studies also included environmental interventions (e.g. addressing food service) and/or service-level interventions involving school nurses. Interventions within the community, school and care outside of school hours, home, childcare or preschool/nursery/kindergarten were eligible. They included studies that compared diet or PA interventions, or both with a non-intervention control group who received usual care or another active intervention.	Children aged 0–18 years in various settings, mostly school-based (43 of 55 studies), but also home, community, health service and care settings. Most studies took place in HIC, especially the United States and Europe, but also UMIC and LMIC.	A meta-analysis of 37 studies (n=27 946 children) showed significant reductions in adiposity (measured as BMI or BMI z-score) (SMD: -0.15; 95% CI: -0.21, -0.09). Subgroup analyses by setting showed the greatest overall effect for education only (SMD: -0.14; 95% CI: -0.21, -0.08) compared to education plus other setting and non-education setting. Subgroup analyses by intervention type showed the greatest overall effect for combined PA and dietary interventions (SMD: -0.18; 95% CI: -0.27, -0.09) compared to PA alone (SMD: -0.11; 95% CI: -0.19, -0.02) with no significant effect for diet alone.

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Watkins et al., 2015 (154)	4.1	This literature review of nutrition aspects of 10 school feeding programme studies concluded that these can be effective in improving anthropometric and biochemical nutrition-related outcomes.	The review included 10 RCTs and CBA studies published between 1962 and 2011.	In-school meals and take-home rations (e.g. school lunch or breakfast, milk supplement, meat or other locally available foods that are rich in energy/protein as supplements).	Primary school children in low- and middle-income countries in Africa, Asia and Latin America	Among the 10 studies measuring anthropometric outcomes, small but significant improvements were seen in height/stunting in 7 of the studies and on weight/underweight in 6 of the studies. Nearly all of the food supplementation studies that reported significant height and weight gains included an animal-based product, not usually included in school feeding programmes in low-income countries. Spill-over benefits were observed for younger siblings indicating that school feeding could have an important role in promoting the health of the next generation. Incorporating findings from other related systematic reviews, the authors concluded that the largest effects were seen for in-school meals on height/stunting, weight/underweight and for MMN fortification on iron status, anaemia/haemoglobin, vitamin A status and zinc status. Take-home rations, MMN fortification or powder had some effect on height/stunting and weight/underweight, whereas in-school meals and MMN powders had some effect on various micronutrient-related outcomes.

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Whittemore et al., 2013 (127)	3.1, 3.3	This systematic review of 12 school-based obesity prevention programmes using internet-based interventions found that such programmes were effective at improving health behaviours of adolescents, at least in the short term.	The review included 12 empirical studies with a comparison group, published between 1999 and 2012.	Internet-based obesity prevention programmes including content on nutrition and PA (alone or combined); 5 compared a school-based Internet obesity prevention programme to a no-treatment control group, 3 studies compared an Internet programme to traditional classroom education, 2 studies compared an Internet programme to a print program, and 2 compared 2 different Internet programmes.	Adolescents aged 12–18 years (mean age 14.7) at schools in the United States and Europe	Overall, school-based internet obesity prevention programmes were effective in improving health behaviours of adolescents in the short term (<3–6 months). Improvements in self-reported dietary behaviour (e.g. intake of SSB, F&V, fast food, fibre or fat, skipping meals) and PA were reported for the majority of programmes (10 programmes, 83%), but only 7 programmes (58%) demonstrated positive outcomes in the internet group compared to the control. Improvements in adolescents' self-efficacy for healthy eating or being physically active were reported in programmes that targeted self-efficacy (3 programmes). Of the 4 studies in which the effect on BMI was evaluated, only 1 study showed a significant decrease. In 2 of the 3 studies that compared the Internet obesity prevention programme to traditional education, the internet intervention had a greater effect on select health behaviours including increased PA and decreased BMI.
Williams et al., 2013 (67)	1.1, 2.2, 4.1	This meta-analysis of 21 school-based diet- and PA-related programmes found that the multifaceted programmes gave significant reductions in weight-related outcomes.	The review included 21 studies (RCTs, CBA studies, cohorts and cross-sectional studies) published in 2003 or later.	Of the 21 studies, 10 focused on diet (e.g. school lunches, breakfast programmes, school nutrition guidelines), 5 on PA (e.g. PE, walking school bus scheme) and 6 on both programme areas. Of the 16 diet-related studies, 13 focused on policies, of which 8 evaluated school lunch or breakfast programmes targeting children at risk of undernutrition and 5 evaluated policies related to increasing availability of healthy foods and beverages or decreasing that of unhealthy foods and beverages within schools.	Children aged 4–11 years in primary schools, mostly in the United States but also in Australia, Canada, Italy, Mexico and the United Kingdom.	The pooled results of diet-related programmes were mixed. Participation in the lunch programme gave a non-significant rise in BMI z-score, while participation in the school breakfast programme gave significantly lower BMI z-score (-0.08; 95% CI: -0.143, -0.017; 5 studies). Exposure to other diet-related policies targeting the availability of foods in schools gave a non-significant decrease in BMI z-score. The pooled results of PA programmes showed a small but non-significant decrease in BMI z-score. The heterogeneity of combined diet and PA programmes prevented further meta-analysis, but these programmes demonstrated promising results, particularly those which involved stakeholder involvement and engagement with families. The authors conclude that diet- and PA-related policies need to be situated within more complex approaches to preventing obesity and to focus on multiple factors and levels of influence.

AUTHOR, YEAR	NFSI ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Wolfenden et al., 2016 (106)	2.3	This Cochrane systematic review of 10 studies of strategies aimed at improving implementation of healthy policies, practices or programmes in child care centres was unable to find sufficient evidence to draw conclusions regarding their effectiveness at improving implementation or improving staff knowledge, attitudes and skills.	The review included 10 randomized and non-randomized studies with a parallel control group, published between 2002 and 2014.	Interventions to improve the implementation of child care-based healthy eating, PA and obesity prevention policies, practices or programmes (focusing on healthy eating, PA or both) by staff of centre-based child care services (e.g. educational materials, educational meetings, audit and feedback, opinion leaders, small incentives or grants, educational outreach visits or academic detailing).	Children aged <6 years (n=2829) and childcare service staff (n=457) in centre-based child care services (i.e. preschools, nurseries, long day-care services and kindergartens) in the United States, Australia and Ireland).	The evidence was insufficient to draw conclusions regarding the effectiveness of the interventions to improve the implementation of policies, practices or programmes that promote child healthy eating, PA and/or obesity prevention, or to improve the knowledge, skills or attitudes of child care service staff. No strategy improved the implementation of all components of the obesity prevention programmes; however, 7 out of 8 studies that compared an implementation strategy to usual practice (as opposed to alternative strategies) reported significant improvements in the implementation of at least one component relative to control. The results of the 3 studies investigating effect on child nutrition outcomes (fat intake, energy intake, BMI, body weight) were ambiguous, with only 1 study reporting improvements.
Wolfenden et al., 2017 (107)	2.3	This Cochrane systematic review of 27 studies of strategies for enhancing the implementation of school-based policies or practices targeting risk factors for chronic disease was unable to find sufficient evidence to draw conclusions regarding their effectiveness at improving implementation or improving staff knowledge, attitudes and skills.	The review included 27 randomized and non-randomized studies with a parallel control group, published between 1988 and 2017.	Interventions to improve the implementation of child care-based obesity prevention programmes (focusing on diet, PA, overweight or obesity, tobacco or alcohol use) by school staff (e.g. educational materials, educational meetings, the use of opinion leaders, external funding, local consensus processes and tailored interventions).	Children aged 5–18 years (n=29 181) and school staff (n=1347) in the United States, India, Australia, Canada and South Africa.	The evidence was insufficient to draw conclusions regarding the effectiveness of the interventions to improve the implementation of policies, practices or programmes for PA, healthy eating, obesity prevention, tobacco use prevention or alcohol use prevention, or to improve the knowledge, skills or attitudes of child care service staff. The majority of included trials reported significant improvements in at least one implementation outcome measure. Regarding dietary intake outcomes, 11 out of 14 studies reported improvements on at least one measure of dietary intake. Regarding overweight, obesity or adiposity outcomes, 7 of 9 studies reported no between-group differences.

AUTHOR, YEAR	NFS ESSENTIAL CRITERIA	ONE SENTENCE SUMMARY	STUDY TYPES	STUDY INTERVENTIONS	STUDY SETTING AND POPULATION	RESULTS OF REVIEW
Yip et al., 2016 (733)	3.1.3.3	This systematic review of 17 preschool and school-based studies indicated that peer-led nutrition education programmes have potential to improve knowledge, self-efficacy and attitudes towards healthy eating.	The review included 17 studies published in 2002 or later of programmes with a peer component, most of which used a pre- and post-test design and control groups.	Peer-led nutrition education programmes.	Children aged 5–18 years in kindergarten, primary and secondary schools in Canada and the United States.	Positive results were observed in those studies measuring satisfaction and behaviour change as well as self-esteem. Improvements immediately post-programme were observed for intake of F&V, SSBs or fats, and self-reported habit and behaviour scores in 11 out of 13 studies reporting on these measures, but these changes were not maintained over time. Significant results were observed for anthropometric measures (BMI, BMI z-score, waist circumference) or other biological measures (blood pressure) in all 4 studies measuring these outcomes. A dose-impact relationship was observed in 3 out of 3 studies investigating this aspect.





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